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PUBLIC INTEREST ENERGY STRATEGIES REPORT

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EXECUTIVE SUMMARY

The energy crisis of 2000-2001 caught many people in California by surprise. Electricity prices seemed to suddenly soar out of control and rotating outages were threatened. While much has been written to explain how California got into this energy predicament and much has happened to help get the state out of danger, California's electricity and natural gas infrastructure, the pipelines and power plants and storage facilities that feed the consumer's desire for light and power, is not yet robust.

According to the ***Electricity and Natural Gas Assessment Report***, one of the three mainstream reports, along with this report and the ***Transportation Fuels, Technologies, and Infrastructure Assessment Report***, which feed into the ***Integrated Energy Policy Report***, California's electricity and natural gas infrastructure is performing reliably, although delivering energy at higher prices than those of the 1990's. Actions are needed in 2003 and 2004 to ensure that the electricity and natural gas systems are robust throughout the decade. Can additional environmentally sensitive capacity be supplied to meet future peak demands? What needs to be done so the system can respond more quickly and effectively to unexpected adverse shocks?

Senate Bill 1389 (SB 1389) directs the California Energy Commission to develop policy recommendations for public interest energy strategies to help, among other things, mitigate potential infrastructure problems.

Public interest strategies occupy a unique position in the goods and services landscape. Public energy strategies are actions taken by public agencies to benefit society as a whole. They are actions that would likely not be taken by private industry, at least not to the degree and extent required. By cutting across economic, demographic, and corporate interests, public interest energy strategies hope to ensure that public benefits like clean air, clean water, and affordable electricity and natural gas will be available for all Californians.

PUBLIC INTEREST ENERGY STRATEGIES

The strategies presented in the ***Public Interest Energy Strategies Report*** are those called out in SB 1389. These strategies include, but are not limited to:

- Energy efficiency and conservation;
- Load management;
- Renewable generation technologies;
- Research, development, and demonstration and the commercialization of new technologies.

In addition to these strategies, the ***Public Interest Energy Strategies*** chapter, "International Markets," reports on the work going on to open up foreign markets to

California energy businesses. Still other public interest strategies are discussed in the ***Electricity and Natural Gas Assessment Report*** and the ***Transportation Report***.

GOALS AND TARGETS

State agencies generally agree on a number of goals for a revitalized electricity and natural gas market. Many of these goals and targets are presented in the ***Energy Action Plan*** which was put forward by the Energy Commission, the California Public Utilities Commission (CPUC), and the California Consumer Power and Financing Authority (CPA) in April, 2003. The ***Energy Action Plan*** identifies public interest strategies:

- Meet California's energy growth needs while optimizing energy conservation and resource efficiency and reducing per capita electricity demand,
- Accelerating the state's goal for renewable resource generation,
- Promote customer and utility owned distributed generation,
- Ensure a reliable supply of reasonably priced natural gas, and
- Upgrade and expand the electricity transmission and distribution (T&D) infrastructure and reduce the time it takes to get needed facilities on line.

When choosing among these strategies, it is important to assess the tradeoffs that may occur between the interdependent risks: energy shortages, total costs, and environmental degradation. By definition, public interest strategies involve either public subsidies or public agency intervention in markets. To maximize the cost-effectiveness of these subsidies and to minimize public intervention into markets, the strategies that best balance these overall risks should be pursued first.

Demand Side Management

California is a leader in the nation in terms of energy efficiency policies and achievements. California has a public benefits funding system and strong complementary strategies between public benefit programs and building and appliance efficiency standards. The state has an excellent track record in measuring demand and estimating load growth. Yet energy efficiency impacts and demand-side management (DSM) programs will have to stand up to much greater scrutiny if Californians are to rely on these programs to displace power plants.

DSM programs are designed to achieve two basic objectives: reduce overall energy consumption by promoting high-efficiency equipment and building design, and achieve load reductions by changing the patterns of energy use, primarily at times of peak demand. DSM can be applied to both electricity and natural gas.

This report presents trends, challenges, and possible policy recommendations for two types of DSM: 1) efficiency and conservation, and 2) a specific form of load management called “dynamic pricing.”

Energy Efficiency and Conservation

The electricity crisis led to a dramatic decline in electricity consumption in 2001 compared to 2000. Studies show that much of this decline grew out of the willingness of the public to act out of civic concerns and altruistic motives. Residential customers cut use by roughly 6.5 percent while commercial customers reduced consumption by 5 percent over 2000 levels. Even in the absence of a day to day energy crisis and the media exposure surrounding such a crisis, persistence of some behavioral changes is continuing. Still, overall, energy use is once again climbing.

Findings

- Overall electricity growth during the next decade is expected to start out at approximately 2.2 percent and level off to an average of 1.4 percent.
- Over the next 10 years, natural gas used for non-electricity-generation purposes is expected to increase at a rate of 0.6 percent per year.
- A doubling of current program spending on electricity-oriented efficiency programs could reduce peak load by an additional 1,700-1,800 megawatts (MW) over the next 10 years a 12 percent reduction in projected demand growth.
- The commercial sector accounts for 35 percent of the state’s electricity consumption.
- Residential and commercial air conditioning and lighting contribute the most to peak demand.
- A doubling of current program spending on natural gas efficiency could cut the growth in natural gas demand by 5 percent over the next decade.

Challenges

California needs to continue to invest in energy efficiency. Support for increased energy efficiency funding should be conditioned on several additional developments if the state is to rely on these programs to displace the need for additional power plants:

- Creation of a CPUC proceeding to establish a strategic framework for energy efficiency and program designs and multi-year funding.
- Unbiased, realistic estimates of expected program savings impacts for efficiency to be included in resource plans. This requires greatly expanded and redesigned measurement and evaluation processes.

- Without understanding when, where, and why energy demands are changing, crucial decisions about where additional resources may be needed will be compromised. Social science research that links economics with sociology, anthropology, and psychology along with expended data collection should be supported.
- Historical achievements of past energy efficiency programs and current market data suggest that a large fraction of California's anticipated load growth could be displaced by increasing synergies between energy efficiency, pricing reforms, and load management programs, particularly dynamic pricing. Energy efficiency needs to be made more responsive to real time needs.

Strategies

The ***Energy Action Plan*** proposes a "loading order" of energy resources that puts energy efficiency and conservation first in line. As California transitions back into an integrated resource planning framework, establishing a state goal will serve to guide statewide policy in efforts to reduce per capita energy consumption. The ***Energy Action Plan*** proposed nine actions to "bend down the curve" through optimized efficiency and conservation. Improving air conditioner efficiency by 10 percent and improving new and remodeled building efficiency by 5 percent will achieve only a small fraction of the additional peak demand reduction that is available with additional public goods funding. Additional strategies will be needed if the full 1800 MW of cost-effective demand reduction achievable with a doubling of current funding is to be realized. A series of strategies targeting new and existing buildings, customers, and program planning is drawn from the chapter's findings and conclusions.

Dynamic Pricing

California's electricity demand does not respond quickly and effectively to changes in price. If there is a severe shock to the system, such as some combination of extreme temperature and unforeseen facility outages, power supplies become tight. The result is that wholesale costs of power may instantaneously rise, but this rise does not usually bring about an appreciable drop-off in demand. Though there was a reduction of electricity demand in the energy crisis of 2000-2001, studies reported in Chapter 2 show that this reduction was motivated more by civic concerns and altruistic attitudes - voluntary emergency conservation - than by price increases.

Following the energy crisis of 2000-2001, the state began to search for technological and regulatory solutions that would hedge against future electricity supply disruptions by allowing consumers to respond to the actual system price of electricity. One of these solutions was the implementation of dynamic electricity tariffs.

Currently, pilot tests to determine customer acceptance and anticipated saving of dynamic rates for residential and small commercial customers will be completed by mid 2004. An evaluation of critical peak pricing (CPP) rates currently available to large industrial and commercial customers is also under way.

Findings

- Time-based or dynamic pricing rates could help large commercial and industrial customers reduce their peak electric demand 500 MW by 2005.
- Additional tariffs and programs for all customer classes and refinements in equipment that would allow customers to respond to dynamic prices could reduce peak demand by about 2,500 MW by 2007.
- Installing advanced meters to support dynamic pricing rates will produce improvements in customer service by reducing the cost of billing, reducing down time during outages, and giving customers more accurate information on the daily fluctuations of energy prices.

Challenges

Key issues that need to be resolved regarding the implementation of dynamic pricing include:

- Should dynamic rates be made voluntary, mandatory, or simply the default rate choice for some customers?
- Does it make sense to install advance metering and automatic control equipment on a widespread basis, or only to those customers who choose a dynamic tariff?
- If given the choice, will enough customers choose to switch to a time-of-use tariff to produce the desired benefits?
- Will system operators be able to rely on widespread customer response to high prices?

In addition to these issues, there exist barriers to widespread deployment of CPP rates. Examples of some of these barriers include low customer awareness of the benefits of switching to these rates and a lack of consensus on the cost effectiveness of installing advanced metering.

Strategies

Dynamic pricing may help alleviate the problem of inelastic demand and high peak loads. The Energy Commission recommends a two pronged strategy to continue the exploration of benefits and costs of dynamic pricing: continued joint agency collaboration and educational activities and deployment of advanced metering systems if analyses are favorable.

The joint agency collaboration in a current CPUC proceeding (R.02-06-001) should continue to promote dynamic pricing for those classes of customers who already have advanced metering systems. Phase 2 of the rulemaking should continue to pursue development of the "business case" for advanced metering. A substantial educational effort targeted at the mass market should be designed and undertaken beginning in 2004.

The agencies should complete their review of the costs and benefits of different strategies to deploy interval metering and dynamic pricing by the summer of 2004. These results should be presented to the Legislature along with an offer to help craft legislation that would help guide the deployment of metering systems.

Renewable Resources

Californians prize their environment, and public agencies have worked hard to protect the air, water, and land resources in the state. As stated in the ***Electricity and Natural Gas Assessment Report***, combustion-fired electric generation contributes only 3 percent of all statewide emissions of nitrogen oxides. Additional efficient combined cycle power plants, renewable generation, and DSM will further reduce this figure. Still, with all the progress made protecting the environment there exist problems. For instance, emissions of greenhouse gases - contributors to global climate change - from fossil fuel combustion remain a concern.

As a result of California's Renewables Portfolio Standard (RPS) and efforts by municipal utilities, the proportion of California's electricity that is generated by renewable resources will change. Legislation (SB 1078) has called for renewable energy to increase from 11 percent in 2001 to 20 percent of all retail sales by 2017. The ***Energy Action Plan*** has called for reaching this 20 percent goal by 2010.

Full implementation and acceleration of California's RPS, one of the public interest energy strategies discussed in this report, would result in complex environmental trade-offs. While renewable technologies offer benefits including fuel diversity and reduced emissions, the ***2003 Environmental Performance Report*** notes that there is also the potential need for new transmission connections from rural areas, which may impact land use. Wind energy is "clean" in that it emits no pollutants into the air, yet more work is needed to reduce harm to birds of prey.

Findings

- In 2001, about 10.5 percent of retail electricity sales in California came from renewable energy resources.
- Energy Commission simulations suggest that accelerating the RPS to 20 percent renewable resources by 2010 could reduce the state's reliance on natural gas to

produce electricity in the Western Electricity Coordinating Council region by 5 percent.

- An accelerated RPS could reduce nitrogen oxide emissions from natural gas and coal power plants in the Western Electricity Coordinating Council region by 0.5 percent (31,500 tons) in the coming decade.
- Replacing traditional fossil-fueled generation with renewable energy could reduce emissions of carbon dioxide natural gas and coal used to produce electricity in the Western Electricity Coordinating Council region by 1.5 percent (62,000,000 tons) over the next decade.

Challenges

Expansion of renewable energy faces a number of challenges. Some of the most important challenges include:

- Transmission lines linking renewable energy sites (often in rural locations) with load centers can be costly.
- Not all forms of renewable energy provide the type of power-on-demand that the system counts on for reliably serving California's customers.
- There is a need to reduce bird kills associated with wind energy and improve fish passage and water quality with small hydro facilities.

The impacts of many of these challenges are hard to gage. For example, the impact of transmission constraints on meeting California's RPS goal will be greatly affected by the following issues: 1) the proportion of RPS met by out of state renewable facilities; 2) capacity constraints on transmission paths connecting renewable resources to the Western Electricity Coordinating Council; and 3) whether the so-called "renewable" attribute of an energy plants can be separated from the energy produced by the plant and traded to meet the RPS goal.

Strategies

California needs to meet energy demand and supply needs by using a variety of different strategies. The ***Energy Action Plan*** proposes that California meet demand and supply needs with conservation and efficiency first, renewable energy and distributed generation second, and if necessary, clean fossil-fuel fired central station generation third.

In the next few years, the state needs to pursue a variety of strategies, including:

- Addressing the implications of the CPUC SB 1038 transmission study early in 2004,
- Reevaluating the adequacy of the public goods funds at the conclusion of the first solicitation for RPS to determine if funding should be increased,

- Commercializing research and development of renewable energy storage technologies which enable renewable energy technologies to operate as dispatchable and/or peaking resources,
- Working closely with transmission system operators so renewable power has access to the system, and
- Monitoring RPS implementation for Community Choice Service providers and Electric Service Providers and implementing of SB 1078 by publicly-owned electric utilities over the next two years in order to identify and address potential barriers as they arise.

Research, Development, and Demonstration

Research, development, and demonstration (RD&D) plays a central role in helping California meet the energy goals expressed in SB 1389 and the ***Energy Action Plan***. RD&D produces the technologies that allow California to adopt aggressive goals in energy efficiency, implement load management, integrate renewable energy resources into the power mix, and reduce greenhouse gas emissions.

For decades, RD&D has played an important role in advancing California's energy technologies. As part of electricity deregulation, the California Legislature set aside special funding for public interest RD&D. Public interest RD&D has a number of sponsors, principally within federal and state governments. At the state level, the primary sponsor of electricity-related public interest RD&D is the Energy Commission's Public Interest Energy Research (PIER) Program. The CPUC is developing an RD&D program for natural gas.

PIER works in collaboration with many other organizations as well. Electric utilities are a particularly important partner for PIER because they are in the business of generating, distributing, and selling electricity. Consequently, utilities are in a position to implement many PIER technologies, and their knowledge and relationships with their customers can also be valuable resources in the commercialization process. That is, getting end-use technologies into the market.

PIER funds the development of lower cost end-use energy efficient technologies. PIER also funds the development of renewable energy technologies, as well as the more efficient and environmentally acceptable fossil fuels.

Findings

- Activities of the PIER program help to stimulate the economy by focusing on producing successful commercial products.
- A public interest RD&D portfolio should maintain a focus on near-term development and application.

- Public interest RD&D funding initiatives should be focused in areas where there are other related state programs, such as building standards.
- The most successful RD&D programs are closely tied to policy initiatives.

Challenges

A public interest strategy such as RD&D needs to show successes. **Table 6-1** in the ***Public Interest Energy Strategies*** chapter on RD&D shows 20 commercially successful technologies through 2002 that have been sponsored in part or completely by PIER. A public benefits RD&D program needs to continually leverage public funding and find niche research areas where those dollars will make a difference.

All RD&D projects should have "exit" strategies. For example, RD&D projects must be terminated quickly when the project's goals clearly will not be realized, and there must be an effective management and marketing strategy for those products which do meet their goals.

Strategies

The state needs to continue to look at additional ways to encourage commercialization of promising new technologies. Too often seemingly successful technologies are unable to penetrate the marketplace. Government should become "first buyers" of new technologies that offer benefits to the state.

In addition to this action, the state should pursue the following strategies:

- The state should leverage federal funds and continue to encourage the federal government to promote federal R&D programs that complement the California programs and policies.
- The state needs to develop and endorse a technology certification program for efficient energy technologies. One already exists for environmental technologies at the California Environmental Protection Agency.

ADDITIONAL PUBLIC STRATEGIES

International Energy Markets

The Energy Commission provides assistance to small, mid-sized, and some larger energy companies to help them export their technologies, products, or services to international markets. While technically not a "public interest" program, the international energy markets program works to boost economic activity in the state. Many smaller California companies do not fully understand international financing techniques and have trouble competing on a level playing field with Japanese and European companies which often are heavily supported by their governments. Putting these firms on an even footing with foreign firms can substantially increase their market share.

Findings

- For 12 distinct energy sector categories, such as wind and geothermal, California represents a significant portion of all U.S. energy companies.
- A recent survey of 152 California energy companies indicates that international markets account for an average of 24 percent of total sales, a percentage large enough to make or break a small to medium size business.
- Capital investments in new power plants by large independent power producers have fallen off in recent years.
- Many energy industries in California are shifting their attention away from domestic markets and towards international markets.

Challenges

There are several international trends that could be taken advantage of by California energy companies. One such trend is greenhouse gas policies and global climate change.

An emission trading policy has emerged from the Kyoto Protocol, an international agreement that contains legally binding greenhouse gas emission caps for 39 developing countries, including China and India. This emission trading policy allows national governments and companies to trade emission credits. The goal of this trading is to reduce overall greenhouse gas emissions. What this means to California energy companies is that energy efficiency, renewable energy, cogeneration, methane recovery, and fuel conversion projects can earn credits that can be banked to meet a country's own goals and/or sold to foreign governments or private companies thus increasing the attractiveness of these projects.

Strategies

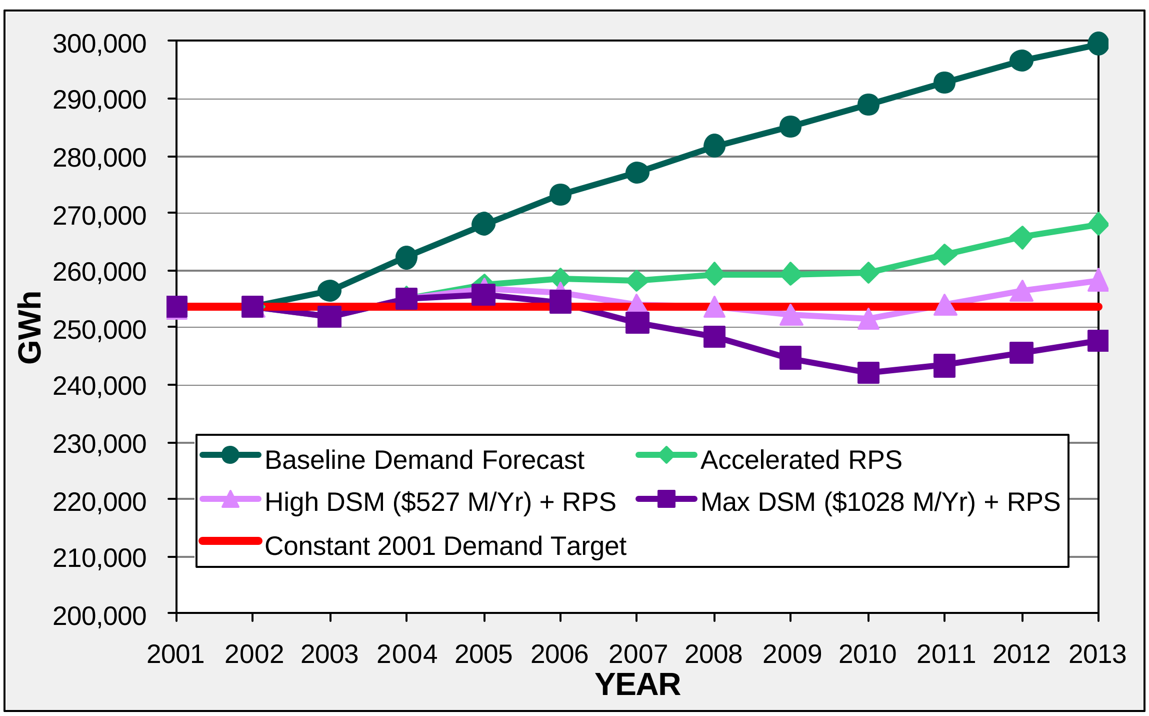
The Energy Commission should explore ways to use the greenhouse gas emission trading mechanism to improve financing of international energy projects for California businesses. There is also an opportunity to develop a joint air quality strategy with Mexico to address how renewable energy, energy efficiency, and new technologies could improve the energy and air conditions on the California-Mexico border.

CONCLUSION

Senate Bill 1389 directs the Energy Commission to evaluate "public interest energy strategies" as part of a much larger effort to establish a unified multi-agency energy policy for California and to recommend a list of legislative actions needed to help realize this policy. Public interest energy strategies are defined in SB 1389 as energy efficiency, load management, renewable generation, and public interest research and development. These strategies are seen as ways of helping Californians avoid being subjected to sudden price spikes, fuel shortages, and other disruptions of service brought about by the type of factors that contributed to the state's energy crisis of 2000-2001.

In formulating a statewide energy policy, state energy agencies have proposed specific goals and targets for energy efficiency, load management, and renewable generation. For example, a CPUC proposed ruling on July 3, 2003 (Rulemaking 01-08-028) envisions meeting 100 percent of California's energy demand growth over the next 10 years through a combination of energy efficiency, demand response, and renewable resources. Preliminary staff analysis reveals that this goal could be met through a combination of increased online renewable generation and increased investment in energy efficiency measures in the amounts shown in the following figure.

Annual Statewide Energy Demand (GWH) under DSM and Accelerated RPS Scenarios



In addition, the introduction of dynamic pricing is expected to result in substantial peak savings. If the appropriate tariff structures are implemented, large commercial and industrial customers would be able to reduce their peak electric demand 500 MW by 2005.

Public interest energy strategies are not without their downside. Both energy efficiency and conservation can be difficult to measure, monitor, and evaluate. Also, while demand reductions from traditional load management programs were relatively straightforward to quantify, the impacts of dynamic pricing face several hurtles before it can be implemented on a large scale. In order to realize the full value of DSM, there needs to be improvement in the ability to forecast demand so that demand reductions can be counted on in the future. And, there are development and implementation costs associated with DSM which must be compared to the costs of new energy facilities. Even renewable resources are not without their environmental impacts. Still, even with these problems, public interest energy strategies hold great promise for Californians.

CHAPTER 1: INTRODUCTION

PURPOSE

The electricity, natural gas, and transportation analysis done as part of the ***Integrated Energy Policy Report*** has identified future energy infrastructure concerns. Public interest energy strategies, such as demand-side management, renewable energy, and research, RD&D may offer solutions to these concerns.

This ***Public Interest Energy Strategies Report*** responds to SB 1389, which directs the Energy Commission to rely upon forecasting and assessments performed in the ***Electricity and Natural Gas Assessment Report*** (Pub. No.100-03-014D) as the basis for analyzing and developing policy recommendations for the "public interest energy strategies" listed below:

- Achieving energy efficiency and conservation;
- Implementing load management;
- Pursuing research, development, demonstration, and commercialization of new energy technologies;
- Promoting renewable generation technologies;
- Reducing statewide emissions of greenhouse gases (GHG) and addressing impacts of climate change on the state;
- Stimulating state energy-related business activities; and
- Protecting and enhancing the environment. (Pub. Resources Code § 25305)

Note that the Energy Commission interprets these more as *goals* than *strategies*. The legislation specifies that this report shall include in-depth analyses of three strategies for realizing broad public interest objectives: energy efficiency; renewable resources; and energy RD&D. See the ***Transportation Fuels, Technologies and Infrastructure Assessment Report*** (Pub. No.100-03-013D) for a discussion of transportation related energy efficiency and RD&D.

Senate Bill 1389 also asks for a description of international energy market prospects, an evaluation of Energy Commission export promotion activities, and an assessment of energy industry efforts to enter foreign markets. The legislation directs the Energy Commission to include recommendations for state government initiatives to foster the California energy technology and energy conservation industry's competition in world markets. (Pub. Resources Code § 25303.5)

The value of these public interest energy strategies, as noted in SB 1389, stems from their ability to provide economic benefits; competitive and low-cost reliable services; customer information and protection; and environmentally sensitive electricity and natural gas supplies. In so doing, public interest energy strategies help meet the energy challenges identified in the ***Electricity and Natural Gas Assessment Report***.[1] Senate Bill 1389 recognizes that these measures offer substantial public benefits that are not adequately provided by the private market. In order to ensure that these public benefits are realized, governmental agencies must play a role in the development and implementation of public interest energy strategies.

While public interest energy strategies can produce sizeable benefits to society, they are not without their drawbacks. Public interest energy strategies present risks and costs, not the least of which involves foregone opportunities to spend public monies elsewhere. These strategies also have varying degrees of uncertainty surrounding their effective deployment. This report will present both the benefits and the risks associated with public interest strategies to address California's energy challenges, and will discuss the importance of an administrative structure, measurement and evaluation techniques, and incentives as a means to arrive at and to monitor goals.

CALIFORNIA'S ENERGY CHALLENGES

Overall Supply Picture

California's electricity and natural gas system must supply as much power and fuel as people demand, when they demand it and where they demand it. Providing safe, reliable, affordable energy services requires a balance between consumer demand and energy supplies, supported by infrastructure such as generation, pipelines, transmission lines, storage facilities and fuel sources. Currently, the physical infrastructure is performing reliably, but delivering energy at higher prices than those of the 1990s. Actions are needed in 2003 and 2004 so that the electricity and natural gas systems are robust throughout the decade.

Peak demand for electricity is very responsive to summer temperature variations. In any given year, the electricity system must be prepared for "demand spikes" caused by exceptionally warm weather. Similarly, the natural gas system must have sufficient storage or delivery capacity to meet winter heating demand spikes. Thus, these system peaks drive the need for capacity additions.

Complicating this picture is the interrelationship between natural gas use and electricity generation. Natural gas-fired generation dominates California's electricity mix. The link between the prices of natural gas and electricity means that cycles in and shocks to natural gas prices are transmitted to electricity markets. End-use gas demand peaks in winter and is lowest in summer, which is the opposite of the seasonal pattern of gas demand used for electricity generation. This creates a double peak for natural gas, with the summer peak coming when gas is traditionally being pumped into storage. These two seasonal peaks challenge the industry in its ability to ensure a reliable supply throughout the year. As gas demands grow and storage capacity remains limited, natural gas markets become more volatile and prices rise in both the natural gas and electricity markets.

California’s energy system is also constrained by the delivery systems for electricity and natural gas. For electricity, these limitations include congested transmission paths, local reliability problems in San Francisco and San Diego areas, and insufficient transmission capacity to accommodate new renewable generation. Recent new natural gas pipeline projects have reduced pipeline capacity constraints to California. While the deliverability issue has decreased, the increasing cost of natural gas continues to be a concern even in the near term.

Meeting these peak demands for electricity and natural gas and creating reliable, affordable and environmentally acceptable energy systems, requires both supply and demand-side measures. On the supply side, the challenge is to install additional capacity (new generation, gas supplies, gas storage or gas pipelines or electric transmission) sufficient to meet expected peaks. On the demand side, the challenge is to implement strategies that give customers the tools and incentives to manage their annual and peak energy demands.

In addition, demand for transportation fuels is steadily increasing. The Energy Commission projects that the number of vehicles on our roads will reach over 33 million in California by 2023, up from about 24.4 million in 2002. Meanwhile, vehicle miles traveled will increase from 313 billion miles in 2002 to over 440 billion in 2023. This increasing demand for petroleum fuels presents two serious supply challenges. First, California’s production of petroleum has been declining by about 2 percent a year, and increasingly California must rely upon imports. To make the situation worse, our state’s crude oil refining capacity and marine terminal infrastructure are becoming insufficient to handle our growing need for imports. Strategies to address these transportation challenges will be discussed in the ***Transportation Fuels, Technologies and Infrastructure Assessment Report***.

The Responsiveness of Energy Demand and Supply

California’s most significant energy challenge stems not from supply constraints, but from the inability of both energy supplies and demand to respond quickly to system shocks.[2] Shocks occur as a result of some combination of extreme temperature, extreme drought, unforeseen facility outages, and forecast error, which can create recurring episodes of supply and demand imbalance. Because of their underlying sources, the magnitude, timing, and duration of system shocks are not precisely knowable. Extreme shocks to the energy system make California vulnerable, as we witnessed in the crisis of 2000-2001, to high costs, emergency outages, and a reduction in normal environmental safeguards. Mechanisms that make supply and demand more responsive to changes in the system, in effect acting as shock absorbers, will therefore reduce the likelihood of catastrophic effects that threaten public interest objectives.

The need for public interest strategies arises because the private market does not adequately provide the mechanisms necessary to respond to and absorb adverse system shocks. This is in part because many of the decisions necessary to increase supply and demand responsiveness entail regulatory oversight and approval (e.g., increasing slack pipeline capacity, creating additional gas storage, and implementing demand responsive pricing). This is further exacerbated by the fact that many supply-side players actually profit from market volatility, and lack any incentive to invest in measures that increase the flexibility of the energy system. Public interest energy strategies are therefore needed to address these gaps in what the market alone is able to provide. Public interest energy strategies can expand the menu of options available to increase the ability of energy supplies and demand to respond to adverse shocks, thus alleviating their impact on the economy.

Environmental Challenges

The costs of electricity generation and natural gas production and use in California reflect the cost of mitigating their environmental impacts, to the extent that mitigation has been required. Where mitigation has not been required, environmental effects of energy production and use persist as an externality — a cost not internalized by the cost of power. Environmental issues associated with energy production and use are described in the ***2003 Environmental Performance Report*** and highlighted below.

Air Quality and Global Climate Change. While emissions from power plants, vehicles, and refineries in California have improved with cleaner new technologies and tougher air quality rules, air quality levels continue to be poor throughout the state and emissions of GHGs – contributors to global climate change – remain a concern. During years of drought these emissions increase significantly because combustion-fired generation is needed to replace hydropower. High peak demands also exacerbate emissions because generation brought on-line specifically to serve peak demands are usually less efficient facilities with less effective emission controls.

California's energy system, particularly transportation, is a significant contributor to global climate change. Global climate change, in turn, has a direct impact on California's energy system. Warmer winters mean reduced snow pack and an earlier snowmelt. A resulting decrease in spring snowmelt would make it harder to refill reservoirs, thereby resulting in reduced hydroelectric power production when it is needed most – during summer peaks.

Impacts to California's Water System. Many power generation technologies and transportation-related activities use water resources in a way that can produce significant adverse impacts to California's dwindling water supplies and its equally valuable aquatic resources. Continued use of once-through cooling at existing and repowered power plants, for example, perpetuates impacts to aquatic resources in the coastal zone, bays, and estuaries. New natural gas-fired power plants frequently use fresh water for cooling – often thousands of acre-feet per year – which in turn can cause adverse impacts to local water supplies and fish. Hydroelectric facilities can cause permanent alterations to stream flows, raise water temperatures, alter dissolved oxygen and nitrogen levels, and cause changes to the aquatic environment that harm fish and wildlife populations. Finally, in the transportation sector, oil refineries have been known to discharge toxins into marine environments. Oil tankers transport exotic organisms in ballast water, and spills from tankers and pipelines can have catastrophic effects on fisheries and wildlife. Storm water runoff from roadways carries toxins, petroleates, and metals that can contaminate freshwater systems and estuaries.

Biological Impacts. California's electric transmission lines, natural gas pipeline rights-of-ways, and roadways can lead to significant loss, fragmentation, and degradation of valuable wildlife habitat. Power plants can disturb and permanently remove valuable wildlife habitat, nitrogen deposition caused by the combustion of fossil fuels can trigger cumulative impacts to sensitive plants and wildlife, and while renewable energy technologies offer some environmental benefits, there are environmental trade-offs. Wind energy, for example, is "clean" in that it emits no pollutants into the air, yet continuing impacts to hawks and eagles remain an issue of concern. Finally, cars and trucks are responsible for road kills[3] and the degradation of habitat resulting from emissions (e.g. nitrogen deposition).[4]

GOALS AND TARGETS FOR MEETING ENERGY CHALLENGES

A range of goals and targets have been proposed by several state energy agencies as part of ongoing efforts to address these problems. This report will identify those goals and targets, comment on their appropriateness, propose additional goals, and indicate how these goals and targets may be achieved.

One set of energy goals was set forth in the ***Energy Action Plan***, which was prepared jointly by the Energy Commission, the CPUC, and the CPA in April, 2003. The ***Energy Action Plan*** identified specific goals and targets (or actions) to address the supply and demand imbalances in electricity and natural gas markets. The ***Energy Action Plan*** identifies five general goals for achieving a stable electricity and natural gas infrastructure:

- Meet California's energy growth needs while optimizing energy conservation and resource efficiency and reducing per capita electricity demand;
- Ensure reliable, affordable, and high quality power supply for all who need it in all regions of the state by building sufficient new generation, including accelerating the state's goal for renewable resource generation;
- Promote customer and utility owned distributed generation (DG);
- Ensure a reliable supply of reasonably priced natural gas; and
- Upgrade and expand the electricity T&D infrastructure and reduce the time it takes to get needed facilities on line.

For each of these five goals, the ***Energy Action Plan*** lists a series of actions. These and other specific actions will be discussed in the appropriate chapters of this report.

In another document discussing energy goals and targets, the CPUC's proposed ruling on July 3, 2003 in Rulemaking 01-08-028 endorses the ***Energy Action Plan***'s principle that energy efficiency and renewable generation resources should be first in the "loading order" for meeting California's energy needs. The CPUC's proposed ruling envisions meeting 100 percent of California's energy demand growth over the next 10 years through a combination of energy efficiency, demand response, and renewable generation resources.

Other rulemakings and legislation have also proposed goals and targets separately for energy efficiency, demand response, renewable generation resources and RD&D. For example, the CPUC issued a proposed ruling (Rulemaking 01-08-028) on July 3, 2003, that envisions meeting 100 percent of California's energy demand growth over the next 10 years through a combination of energy efficiency, demand response, and renewable energy. These rulemakings and legislative actions will be discussed in detail throughout this report.

ADDRESSING ENERGY CHALLENGES: THE ROLE OF PUBLIC INTEREST ENERGY STRATEGIES

Addressing California's energy challenges will require integrated and well coordinated public interest strategies.

The strategies presented in this ***Public Interest Energy Strategies Report*** are those called out in SB 1389:

- Energy efficiency, conservation, and load management
- Renewable generation technologies
- RD&D and commercialization of new technologies

It should be noted that the strategies listed above are not inclusive of all possible public interest strategies. Other public interest strategies are discussed in the ***Electricity and Natural Gas Assessment Report*** and the ***Transportation Fuels, Technologies, and Infrastructure Assessment Report***.

When choosing among these strategies, it is important to assess the tradeoffs that may occur between the interdependent risks: the energy shortage, total cost, and environmental risks. By definition, public interest strategies involve either public subsidies or public agency intervention in markets. To maximize the cost-effectiveness of these subsidies and to minimize public intervention into markets, the strategies that best balance these overall risks, should be first pursued.

Demand-Side Management

DSM includes energy efficiency, conservation, and load management. These measures are also collectively referred to as "demand response" strategies because they focus on influencing customer demands for gas and electricity. The primary difference between these measures is that efficiency and conservation are means of reducing overall energy use, whereas load management is a way of shifting energy use in response to the needs of the electric system.

Energy efficiency refers to the permanent installation of energy efficient technologies or the elimination of energy losses in existing systems. Examples include air conditioners that use less energy, building insulation, or new ways of sealing ducts to prevent air leakage. The purpose of pursuing energy efficiency is to deliver the same level of service with less energy. **Energy conservation** refers to behavioral changes in how one uses any energy-consuming appliance, such as turning off lights when leaving a room, or running the dishwasher only when full. The behavioral change may last for a short duration or may be incorporated into a habit or lifestyle.

Load management refers to strategies employed by electricity distribution companies to manage their overall system load by "shaving peaks" and or "filling valleys" on a daily or seasonal basis. Load management makes sense because it is more expensive to purchase energy to meet limited term energy peaks than it is for the utility to sponsor programs or tariffs that encourage customers to either shift or reduce their energy usage during these peak periods. There are three principal types of load management programs being operated in California today: air conditioner and pool pump cycling programs, time-of-use rates, and curtailable rate programs. In the last two years, the energy agencies in California have been working to expand the effectiveness of time-of-use pricing by adding a more dynamic element. "Dynamic pricing" uses price signals to induce customers to cut back their energy use during periods of peak demand and high energy costs. With dynamic pricing in place, electricity prices charged to customers can be adjusted on short notice (typically an hour or day ahead) to reflect changes in the cost of purchasing and delivering electricity. These measures help to make the energy system more flexible by making overall system demand more responsive to changes in supply.

The ***Energy Action Plan*** envisioned that DSM would be first in the "loading order" of resources for meeting future energy needs because, in general, it is the most cost-effective and environmentally sound resource. In the long run, the reduction of load (or demand) growth can delay or eliminate the need for generation capacity or transmission additions. Historical achievements of past energy efficiency programs and current market data suggest that a large fraction of California's anticipated load growth over the next decade could be displaced through a combination of energy efficiency, pricing reforms, and load management programs. By reducing the need for new natural gas-fired generation capacity, we also reduce the chances that volatility in the price of natural gas will create price shocks for electricity. In the short run, DSM provides a means of releasing a pressure valve when energy demand exceeds available supplies, or when energy supplies are constrained and prices soar. This benefit is critical when demand peaks due to unusually warm weather.

DSM is also key to addressing California's energy-related environmental challenges. By using less energy, or using less energy during critical periods, DSM avoids many of the environmental and fuel supply challenges of generating more electricity or consuming more natural gas. Reducing California's demand for electricity benefits air quality and reduces emissions of greenhouse emissions. Reductions in peak load have an even greater effect because they reduce the need to run peaking facilities — typically the least clean generation sources.

The ***Energy Action Plan*** recognized that energy system reliability is not just a supply problem; the system works best when flexibilities are built in on both the supply and demand side. DSM strategies create these flexibilities (or short term "elasticities") on the demand side by providing consumers with incentives and tools to reduce their energy use or reschedule its use to less critical time periods. Giving consumers the ability to truly manage their energy bills will empower consumers, help to curb market power by generators, and result in more stable prices.

DSM strategies are not without their downside. Both energy efficiency and conservation can be difficult to measure, monitor and evaluate. Also, while demand reductions due to traditional load management were more straightforward, dynamic pricing – quite possibly the most valuable form of DSM – faces some challenges before it can be implemented on a large scale. Most importantly, in order to realize the full flexibility-enhancing value of DSM, we will need to improve our ability to forecast the price and/or voluntary emergency demand response we can count on in the future. Furthermore, DSM comes with development and implementation costs which must be compared to the costs of new energy facilities and their environmental impacts.

Renewable Generation and Distributed Generation

Current renewable energy resources in California include wind, biomass, biogas, solar, small hydropower, and geothermal. Geothermal energy provides the largest portion of renewable electricity in California (excluding hydropower larger than 30 MW). Renewable resources provided 11 percent of retail electricity generation in California in 2001. As a result of California's RPS and efforts by municipal utilities, the proportion of California's electricity generated by renewable resources is mandated (SB 1078) to reach 20 percent of retail sales by 2017. The ***Energy Action Plan*** set a more aggressive goal to increase the proportion of California's retail electricity sales produced by renewable resources to 20 percent by 2010.

Like DSM, renewable energy resources can help address California's energy challenges. First, renewable resources can contribute to energy diversity, and therefore system reliability, by reducing dependence on natural gas. Meeting California's RPS by 2017 without incremental DSM energy savings could displace approximately 2.5 percent of the 2013 demand for natural gas used to fuel electricity generation that would otherwise occur in the western states. Accelerating the RPS to 20 percent of retail sales by 2010 could double this western generation effect, raising it to a reduction of 4.6 percent in 2013. In a tight natural gas market, renewable resources can reduce the squeeze that fosters volatility in the natural gas market.[5]

Many renewable energy resources have zero or small fuel costs, in comparison to most conventional generation resources. Hence, renewable energy generators are more able to sign fixed-price contracts linked to the price/forecast of natural gas. The RPS is designed to result in annual solicitations for renewable resources, with updated price/forecast information utilized each year. An increasing proportion of these fixed-price contracts, as envisioned through the RPS, should imply an electricity system that is less exposed to the price volatility of the natural gas market. The degree to which this occurs depends on the specific contract arrangements that are established through the RPS.

Renewable energy avoids some of the environmental risks of conventional generation but introduces others, and full implementation of California's renewable portfolio standard would result in complex trade-offs. Analysis suggests that achieving the RPS could displace 20,000 tons of nitrogen oxide (NO_x) emissions from gas and coal-fired generation in the Western states over the 2004-2013 timeframe. In addition, the generation using renewable resources rather than fossil fuels can reduce carbon dioxide and other GHG emissions associated with global climate change. On the cost side, some technologies require new transmission connections from rural areas, with possible impacts to land use, biological, cultural, and visual resources. Wind energy is "clean" in that it emits no pollutants into the air, yet impacts to hawks and eagles remain an issue of concern and care must be taken in selecting sites for wind generation that do not impact raptor habitat.

The benefits of renewable energy must be balanced with other risks and challenges as well. Renewable energy faces transmission and grid interconnection constraints, cost-effectiveness hurdles, and difficulties with obtaining financing. Also, many renewable resources produce energy on an "as available" basis (e.g., wind turbines produce energy when the wind is blowing), which may not coincide with consumer demand.

Research, Development and Demonstration

RD&D can be defined as the process of advancing science and technology from the initial stages of exploring a concept, through the laboratory and the application testing of components and systems, to the eventual introduction into the market. RD&D is essential to the development of each and every one of these strategies presented in this report. RD&D is what produces the technologies that allow California to adopt aggressive goals in DSM, to integrate renewables into the power mix, and to reduce GHG emissions. These technologies help to protect the environment while simultaneously stimulating energy-related business activities. In this way, RD&D provides the foundation upon which other public interest goals and objectives can be met.

ORGANIZATION OF THIS REPORT

The bulk of this report is organized around the three over-arching public interest energy strategies identified by SB 1389: DSM (separated into a chapter on energy efficiency and conservation, and a chapter on dynamic pricing), renewable energy resources, and RD&D. In general, each chapter includes a review of past trends within the affected markets or industries, a discussion of emerging trends and the implications thereof, an examination of the contribution of each strategy to energy solutions, and a list of findings or policy options. These findings will be used to generate the policy recommendations in the ***Integrated Energy Policy Report***.

This report, as required by SB 1389, also includes a chapter on international energy markets, including a listing of findings, challenges, and a discussion of strategies to deal with those challenges, such as ways to use the emissions trading policy from the Kyoto Protocol to improve financing of international energy projects for California businesses.

CHAPTER 2: ELECTRICITY AND NATURAL GAS CONSUMPTION TRENDS

Few Californians are directly interested in the concept of energy demand. They are interested in cooling their homes, producing goods, or offering services. The purposes of this section are to discuss what drives electricity and natural gas demand and summarize California's forecasted needs for the next ten years. This section will describe trends in the consumption of electricity and natural gas over the past decade to provide perspective on current events and longer-term outlooks. Without understanding when, where, and why energy use and peak demand are changing, we lack crucial information needed for future integrated resource planning. This chapter is organized into the following sections:

- Electricity Consumption Trends
- Electricity Use by Sector
- Electricity End Use
- Natural Gas Consumption Trends
- Natural Gas Use by Sector
- Natural Gas End Use

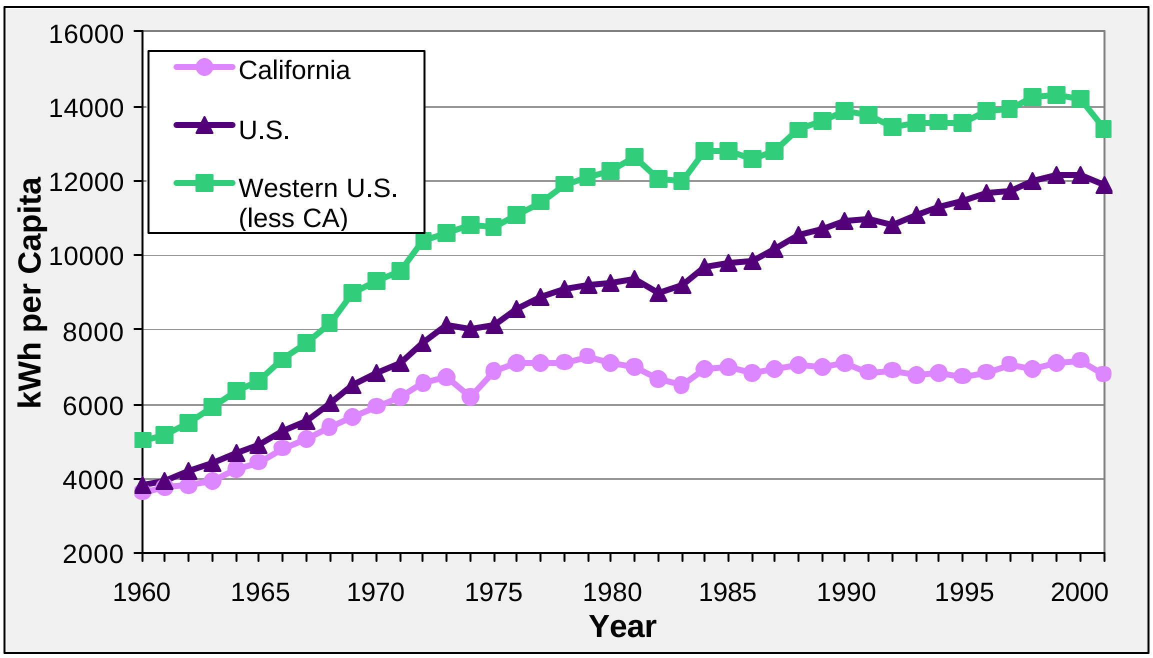
Consumption is measured in two ways—peak demand and overall energy use. Peak demand, expressed in MW, measures the highest power requirement during a specified period of time. Generally peak demand occurs in an afternoon hour on a summer day due to increased residential and commercial air conditioning (AC) loads. This is the amount the system must be able to handle to maintain a stable electricity supply for everyone. The smallest unit of measurement is the kW; 1,000 kilowatts (kW) equals 1 MW. The second measurement is overall energy use, which is expressed in megawatt hours (MWh). While peak demand measures a maximum amount needed at a specific moment, energy use measures the total amount of electricity consumed over a specified period of time, usually an hour.

ELECTRICITY CONSUMPTION TRENDS

Electricity use is a function of demographic and economic change, price trends, weather, and consumer behavior. Californians consumed roughly 253,500 gigawatt hours (GWh) of electricity in 2001 and needed 49,625 MW of peak electric demand[6]. Population and income are the key drivers for the residential and commercial sectors. Increasing personal income allows customers to buy new electrical appliances such as computers, printers, additional televisions, or refrigerators. An increase in the number of businesses, measured by square footage and the use of energy per firm, contributes to commercial sector growth. Other factors influencing commercial energy use are vacancy rates, taxable sales, and population. Industrial energy use is driven by employment and the output of manufacturing plants as measured in value of shipments.

Californians consume less electricity per person than the residents of any other state as shown in **Figure 2-1**. Throughout the 1990s, per capita electricity use virtually held constant, increasing at an average of 0.1 percent each year. Assuming current policies and programs, per capita consumption is expected to hold steady over the next decade. By contrast, national per capita consumption is expected to increase by 0.7 percent annually between 2001 and 2025, according to the Energy Information Administration's ***Annual Energy Outlook 2003***. Peak demand in the state would have been 15,000 MW higher than it was in 2000 had California's per capita electricity demand increased at the same rate as the rest of the country (1.7 percent over the last 25 years).[7] Since the highest daily peak demand depends on how hot temperatures get each summer, per capita use is more often expressed using annual energy consumption (MWh).

Figure 2-1
Total Electricity Use per Capita, 1960-2001



Californians use almost 50 percent less electricity than the U.S. average
Source: Energy Information Agency and California Energy Commission

To better understand trends in how energy is used, we separate total consumption by sector and end-use. Sector refers to the type of energy-using customer (e.g., commercial, residential, etc.), while end-use is a term used to refer to the service desired from the energy (e.g., lighting or cooling).

Electricity Use by Sector

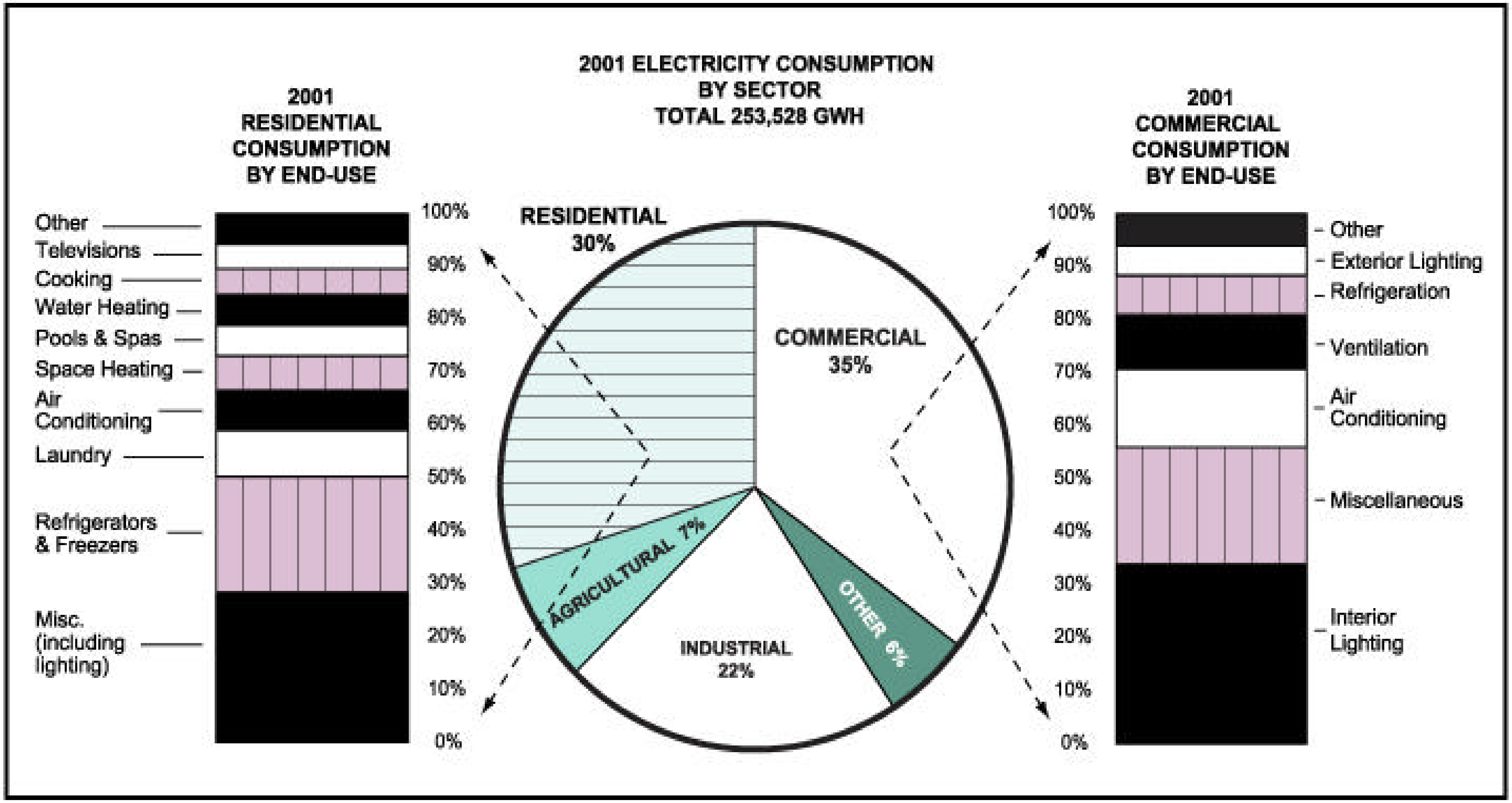
The commercial sector accounts for 35 percent of the state's electricity consumption as shown in **Figure 2-2**. Coming in at slightly lower proportions are the residential sector (31 percent) and the industrial sector (20 percent). Transportation and street lighting account for the remaining 6 percent of electricity use. The residential and commercial sectors become larger portions of the total peak demand, as shown in **Figure 2-3**.

Moderate economic growth is forecasted to resume in 2004, but the robust growth in income and employment of the late 1990s through 2000 is not expected to return.[8] This more modest economic growth, combined with retail electricity rate cuts as bonds are paid off, contributes to demand growth averaging 2.2 percent for 2004 and 2005. Demand growth slows to an average of 1.4 percent for the rest of the forecast period, as retail rates and economic trends stabilize. **Figure 2-4**, showing statewide annual consumption by sector over time, illustrates these factors. This means that by 2013 peak demand may be 8,000-10,000 MW higher than in 2000 and overall consumption will increase by as much as 36,000 GWh. Adding the market reserve requirement to this means that eighteen new 500 MW power plants would be needed to meet this projected demand without new DSM initiatives.

The technology boom of the late 1990s helped fuel nonresidential demand (commercial, industrial, mining, and agriculture sectors taken together) growth of 2.6 percent per year. Growth was even faster in the commercial sector, as California's economy continued shifting away from manufacturing toward a service economy. This commercial growth trend is forecasted to continue, but at a much slower rate. The commercial share of total nonresidential demand is expected to increase to 52 percent over the next decade.

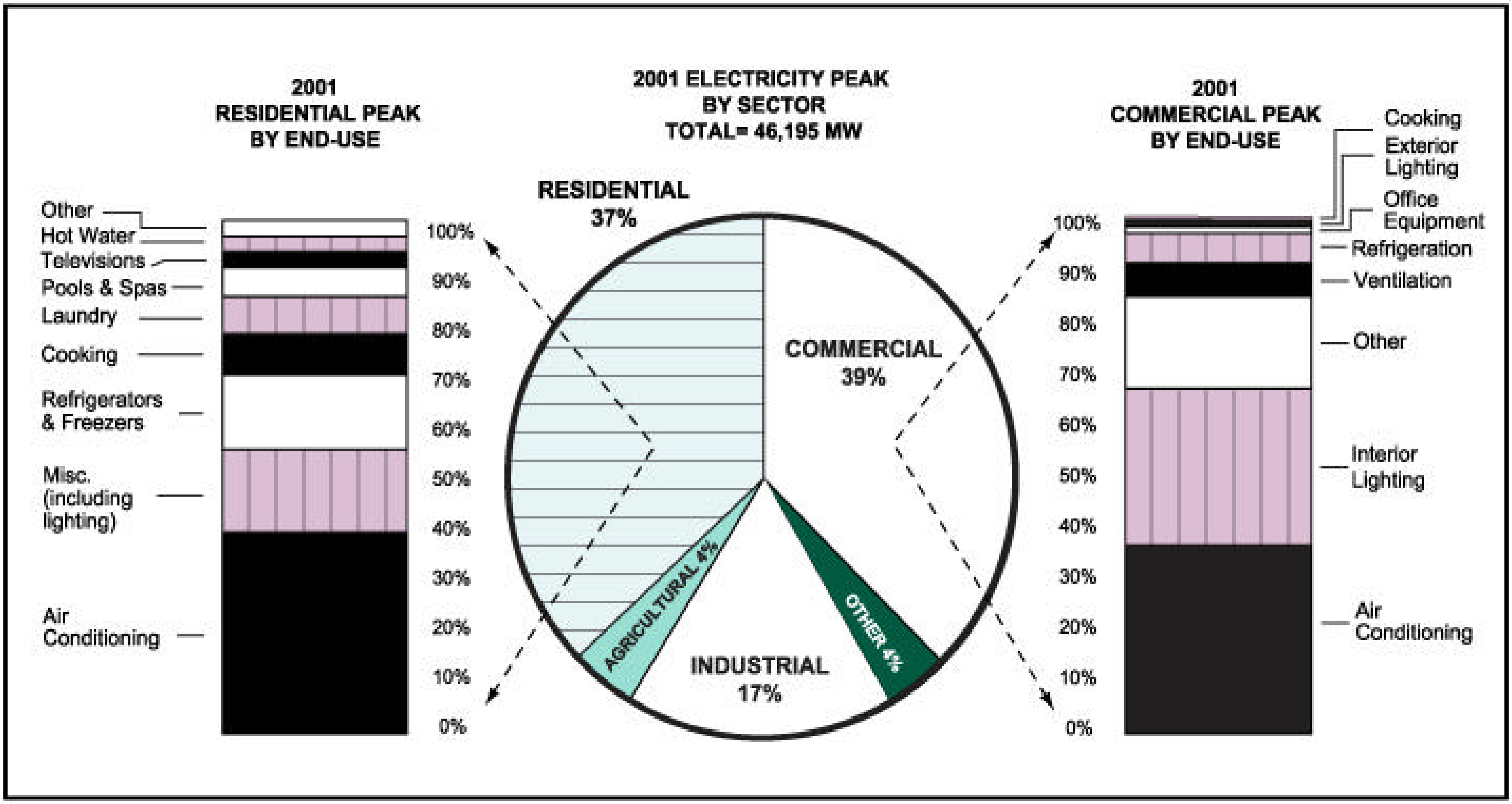
Annual growth rates for peak demand by sector show a similar ordering of sectors. The commercial sector peak grew by 1.7 percent during the 1990s, compared to 1.6 percent for residential and 0.6 percent for industrial. Projected annual growth rates in the 2001-2013 period show the residential sector peak demand growing slightly faster than commercial because of slower economic growth. Projections of possible peak demand problems in the California electricity market in 2007 and 2008 suggest that efforts to achieve peak savings will be crucial over the long run.

Figure 2-2
California Electricity Consumption by Sector and End-Use



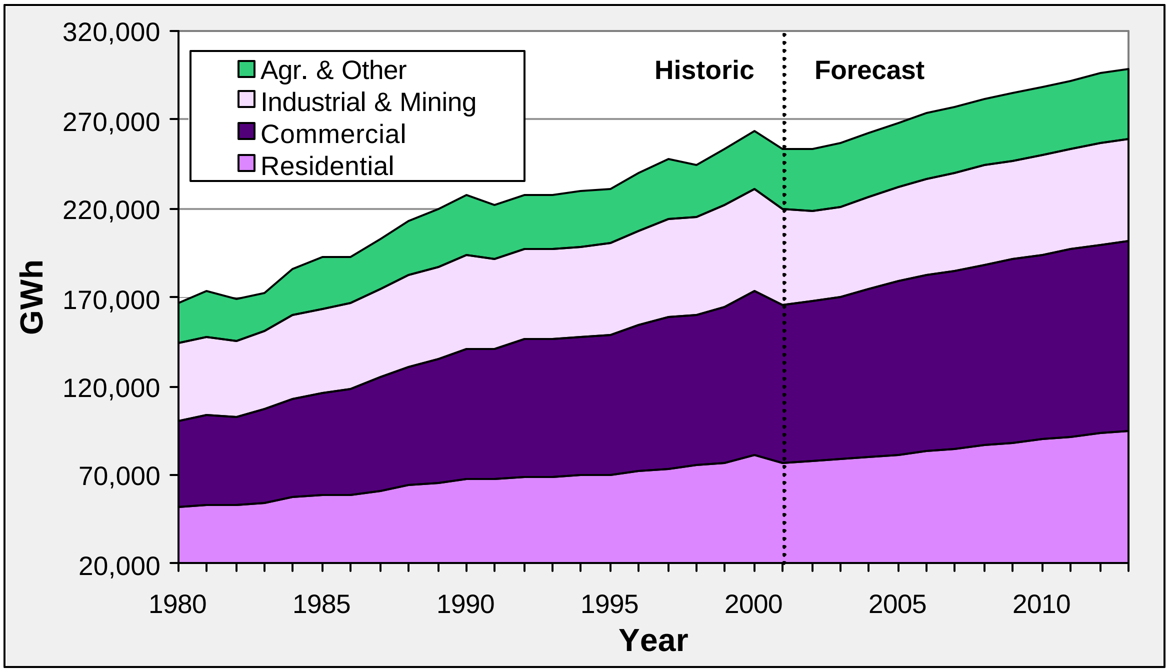
California's commercial sector uses the most electricity, but both businesses and homes use electricity in many different ways.
Source: California Energy Demand Forecast, 2003

Figure 2-3
California Peak Demand by Sector and End-Use



Cooling and lighting California's homes and businesses drives up peak electricity demand.
Source: California Energy Demand Forecast, 2003

Figure 2-4
Electricity Consumption by Sector over Time



Electricity End-Use

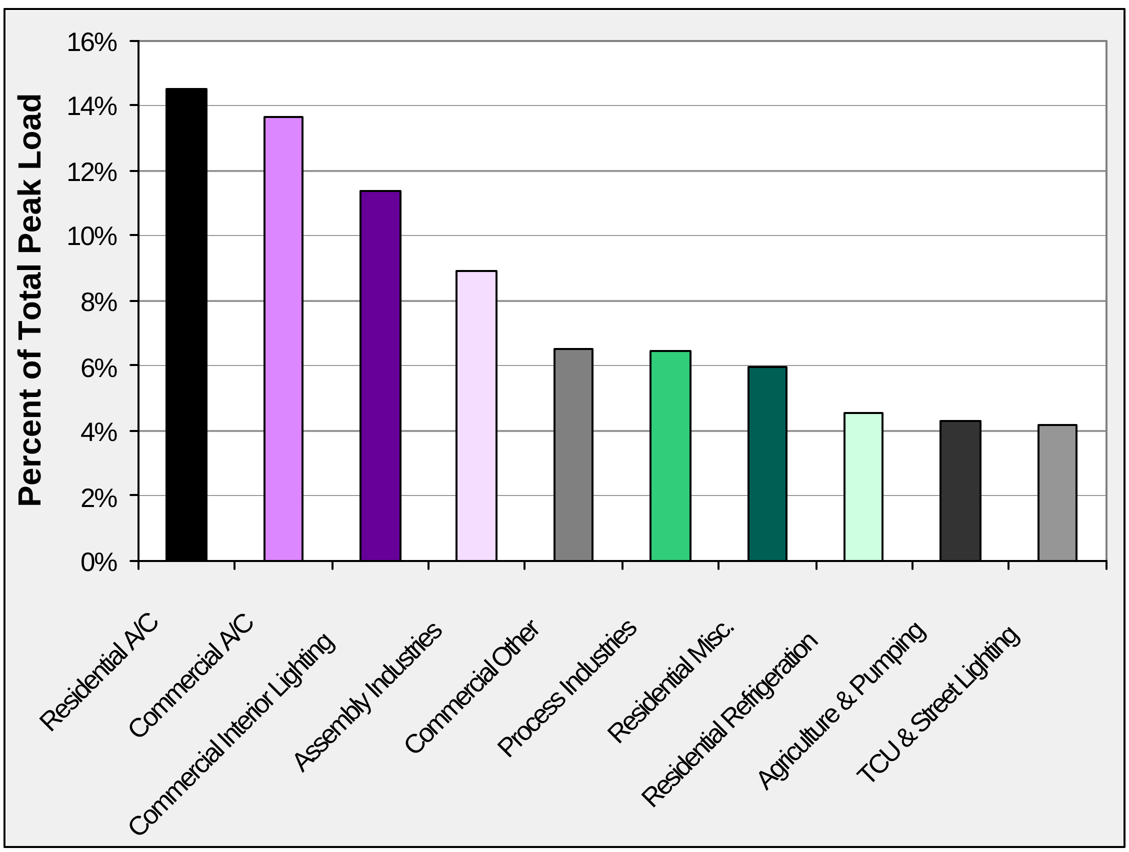
Understanding how the resources are actually used in energy consuming activities known as end-uses is crucial to any discussion on energy efficiency. The greatest uses of both electricity and natural gas are for end-uses in residential and commercial buildings.

The breakdown of electricity consumption into specific end-uses for both the residential and commercial sectors is shown in **Figure 2-2** and **Figure 2-3**. In each case, two end-uses account for most of the electricity used. As shown in **Figure 2-2**, electricity-consuming end-uses in the residential sector are clearly dominated by the categories "miscellaneous" (e.g., lighting, fans, small appliances and consumer electronics) and refrigeration. No other end-uses account for more than 10 percent. Laundry, air conditioning, and space heating are the next largest uses, each accounting for between 6-9 percent of residential consumption. In the commercial sector, as shown in **Figure 2-2**, interior lighting and the "miscellaneous" together similarly account for more than half of total commercial consumption. The commercial "miscellaneous category" includes elevators, escalators, and many other end-uses. Air conditioning is the next largest end-use component of annual consumption (GWh).

Overall residential electricity end-uses apparently have grown slowly compared to growth in housing and equipment, according to scientists from Lawrence Berkeley National Laboratory (LBNL) who compared 1999 end-use breakdowns from Energy Commission models to a residential sector estimate from 1975.[9] Aggregate electricity consumption increased by almost 70 percent in these twenty-five years. Most of this growth was concentrated in the residential "miscellaneous" equipment category (lighting, small appliances, fans, and consumer electronics), clothes dryers, and dishwashers. The increase is likely caused by the increase in the market saturation of these devices and appliances. Surprisingly, both space heating and air conditioning consumption remained relatively constant between 1975 and 1999 as a percentage of total electricity consumption.

In contrast to annual consumption, **Figure 2-5** summarizes the top 10 contributors to peak load. Residential and commercial air conditioning end-uses clearly dominate peak load. Cooling residential and commercial buildings accounts for 28 percent of the total peak load and 36 percent of peak load associated with buildings. Other residential end-uses contributing more than 10 percent to peak total demand are again in the "miscellaneous" category (e.g., lighting, fans, consumer electronics, and small appliances), and refrigeration. Commercial interior lighting is a large contributor to peak demand as well.

Figure 2-5
Major Components of Peak Demand in 2001



Residential sector air conditioning and commercial sector air conditioning and interior lighting are the largest contributors to California's peak demand.
Source: California Energy Demand Forecast, 2003

NATURAL GAS CONSUMPTION TRENDS

California is the second largest consumer of natural gas in the nation, taking delivery of more than 7,000 million cubic feet in 2002. The demand for natural gas in electricity generation remains the fastest growing segment of California's total natural gas demand. About 35 percent of the total gas consumed in California is used in generating electricity. While new power plants are 40-50 percent more efficient than the older units they are replacing, power generation continues to be the lead driver for natural gas demand growth. The growth in natural gas demand for power generation is projected, on average, at 1.5 percent per year. Over the next ten years, use of natural gas at the end-use level, such as heating a home, is forecasted to increase at a rate of 0.6 percent per year, which is less than half the rate of growth for the nation.[10]

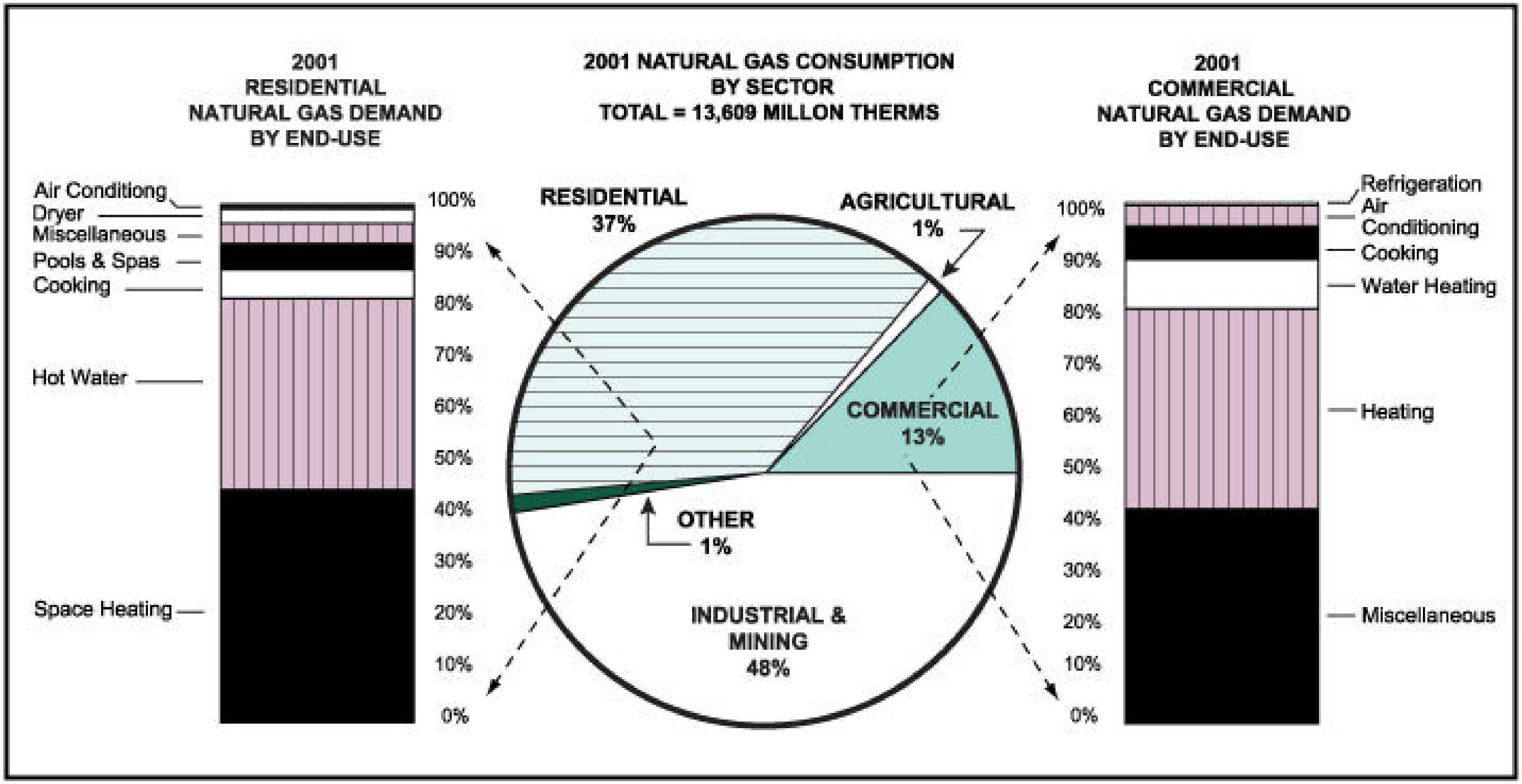
The natural gas market trends changed significantly starting in the summer of 2000. Both the United States and Canada have experienced a volatile natural gas market over the past three years resulting from a combination of longer–term supply and capacity related issues and short-term storage capacity, weather, and rainfall/snow pack conditions. Particularly volatile price spikes could have an indirect impact on residential electricity demand. For example, at certain times the use of portable electric heaters could be less expensive than running a natural-gas fired furnace.

Natural Gas Use by Sector

The combination of industrial and mining consumption accounts for 48 percent of the annual natural gas usage at the "direct" or end-use level, as shown in **Figure 2-6**.[11] (Natural gas for power generation is not included in these calculations.) Residential buildings account for 37 percent of direct use. Commercial buildings and agriculture account for the remaining 14 percent of the total.

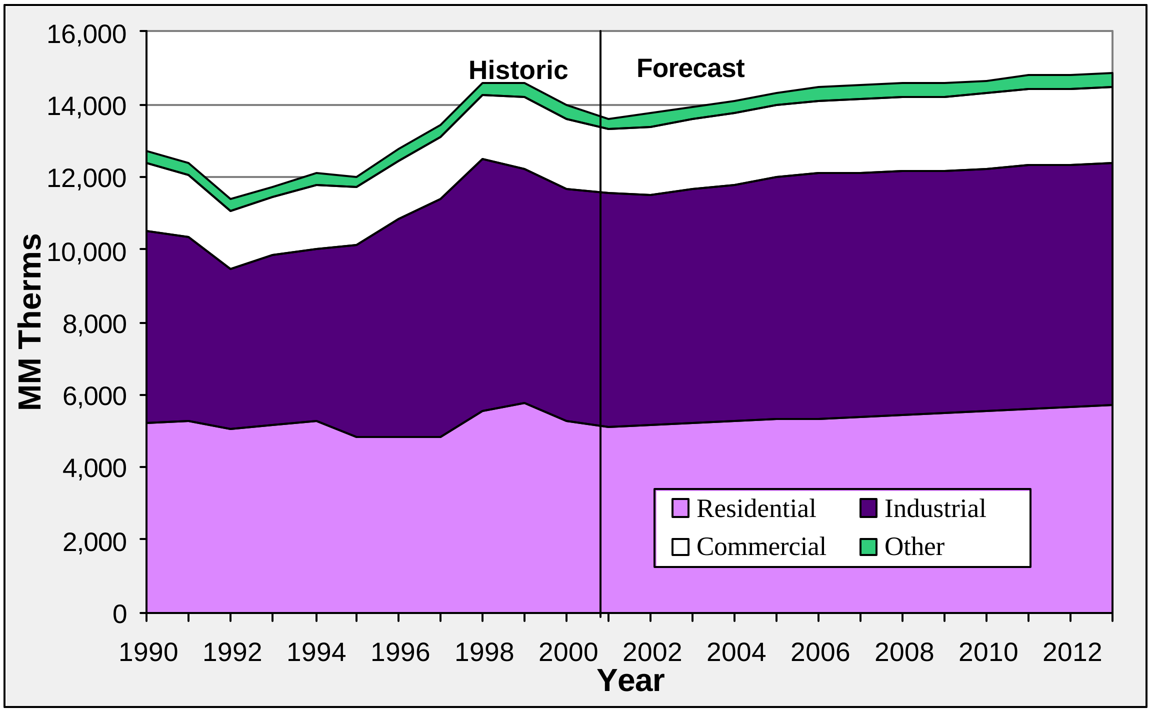
Residential use as a percentage of the total has declined since the early 1990s as industrial use steadily increased. This decline is due in large part to the impacts of building and appliance standards and the small number of new gas appliances entering the market.[12] Going forward, growth is projected to be strongest in the commercial and residential sectors (averaging 1 percent and 0.9 percent respectively) and weakest in the industrial sector (0.1 percent). **Figure 2-7** shows the historic and forecasted trends for direct gas consumption by sector.

Figure 2-6
California Natural Gas Consumption by Sector and End-Use



Beyond space heating and water heating, natural gas use is highly varied.
Source: California Energy Demand Forecast, 2003

Figure 2-7
Trends in Gas Consumption by Sector 1990-2013



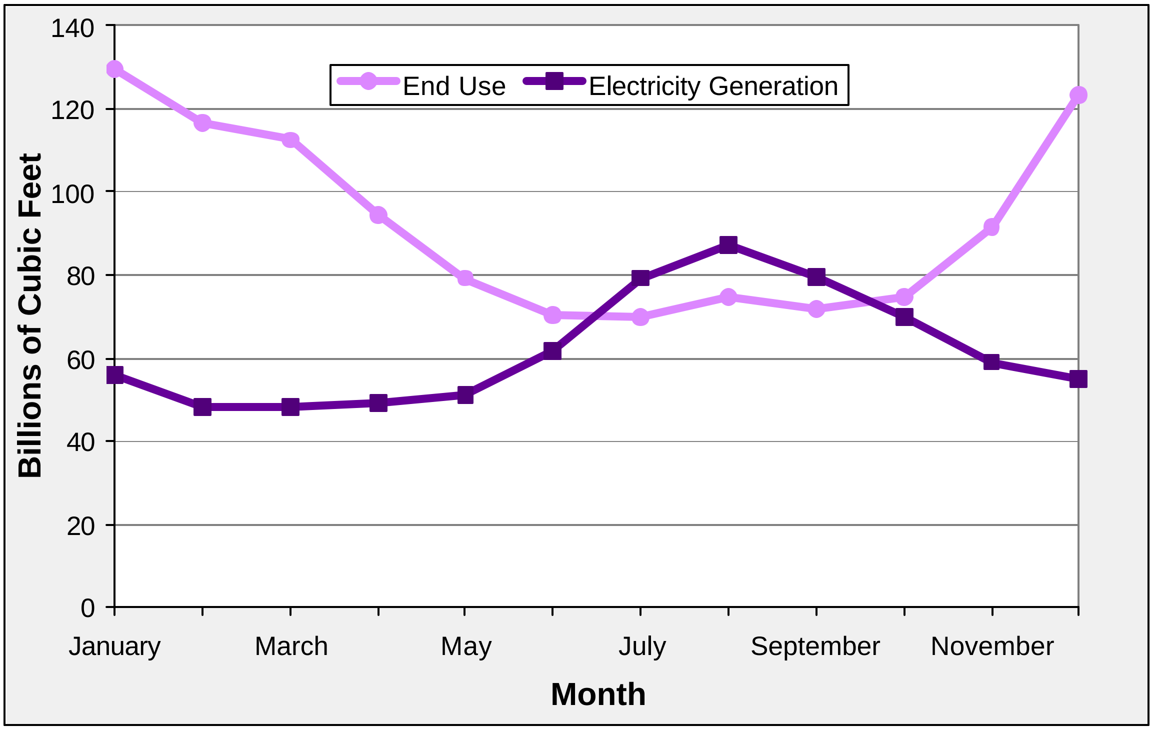
The industrial/mining sector is the largest user of natural gas, but projected growth is stronger in the residential and commercial sectors.
Source: California Energy Demand Forecast, 2003

Natural Gas End-Use

Natural gas end-use consumption (excluding natural gas used in electricity production) in 2001 totaled 13,609 million therms (MTh). Natural gas consumption increased by 1.0 percent annually in the 1990s. A breakdown of natural gas consumption by end-use is shown in **Figure 2-6**. The most significant residential natural gas end-uses are space heating and hot water heating, each of which comprises about 40 percent of all residential gas use. About 85 percent of California homes use natural gas for heating. The commercial sector is more complicated because of the vast diversity of end-uses. The most significant direct commercial natural gas end-uses are heating (35-40 percent) and hot water heating (10 percent). Restaurants account for the largest share of commercial building usage (22 percent), followed by miscellaneous buildings (e.g., auto repair shops, libraries, theaters), offices, hospitals, and hotels.[13] These percentages have remained relatively constant over the last decade.

Historically, natural gas use peaked in winter, driven by heating homes and businesses. The natural gas supply system is designed to provide maximum gas in the winter and to recharge natural gas storage when demand is low. But, the construction of so many natural gas-fueled power plants has created a secondary peak in the summer. The resulting double peak is illustrated in **Figure 2-8**.

Figure 2-8
Natural Gas Consumption in California for an Average Year



Efforts to reduce peak electricity demand, particularly during low hydroelectric conditions, should reduce summer gas demand as well. In fact, summer-oriented energy efficiency may be one of the best ways to reduce the demand for natural gas. Reducing winter peak gas demand for direct end-uses may avoid the risk of gas-supply curtailments to electric generators and enable gas utilities to defer investments in distribution pipeline expansion projects.

CHAPTER 3: ENERGY EFFICIENCY AND CONSERVATION

Households, factory managers, farmers, business people, and building operators are among those making millions of energy decisions each day. Few of these decisions are directly about energy. People are interested in cooling their homes, producing goods, or offering services. Energy efficiency and conservation programs can play major roles in increasing the reliability of the current electricity system for these uses and in reducing the costs of meeting peak demand during periods of high temperatures and/or high prices. Experience has shown that it is crucial that the demand side of the market be able to respond to different kinds of market conditions. Supply side solutions, such as power plants, that maintain large amounts of capacity to meet short-lived variations in demand levels are almost inherently more expensive.

The purpose of this chapter is to assess how energy efficiency and conservation could contribute to a reliable energy system. This chapter will provide a summary of efficiency program spending and savings trends, and describe the remaining efficiency potential that could be achieved. Possible challenges to the reliability of efficiency and conservation and policies that could increase their future certainty conclude the chapter. This chapter of the ***Public Interest Energy Strategies Report*** is organized into the following topics:

- Program Policy and Expenditure Trends
- Savings Trends
- Energy Crisis Initiatives, Achievements, and Lessons Learned
- Potential for Additional Achievable Energy Efficiency and its Value
- Challenges to Achieving Reliable Energy Efficiency
  - Improving the Certainty of Energy Efficiency and Conservation
  - Delivering Energy Efficiency and Conservation More Effectively
- Setting Statewide Goals for Achieving Future Reliable Energy Efficiency
- Strategies for Realizing the Goals
- Conclusions

EXAMPLES OF ENERGY EFFICIENCY:

- Replacing incandescent light bulbs with compact fluorescent bulbs, which deliver equivalent light using 70 percent less electricity.
- Installing new variable speed chillers that deliver cooling to buildings using 40 percent less energy than typical chillers.
- Identifying and repairing leaks in ductwork, which can improve heating and cooling efficiencies by as much as 25 percent.

EXAMPLES OF CONSERVATION:

- Raising a thermostat from 75 º F to 80 º F for air conditioning on a hot summer day.
- Waiting until the dishwasher is full to run.
- Turning lights off when the room is not in use.

Energy efficiency and conservation fall under the heading of DSM. This term encompasses several energy demand-reducing activities: energy efficiency, conservation, and demand responsive actions such as load management or load shifting. DSM programs are designed to achieve two basic objectives: reduce overall energy consumption by promoting high-efficiency equipment and building design, and achieve load reductions by changing the patterns of energy use, primarily at times of peak demand.

Both efficiency and conservation programs can achieve energy savings, but in different ways. Energy efficiency typically refers to the permanent installation of energy efficient technologies or the elimination of energy losses in existing systems. The aim of energy efficiency is to maintain a comparable level of service, but reduce energy usage. Energy conservation involves using less of a resource, usually by making a behavioral choice or change. The change may last for a short duration or may be incorporated into a habit or lifestyle.

DSM also can take the form of “load management” or “load shifting.” A customer reduces or curtails load in response to an emergency signal from a service provider or grid operator. This is different from conservation in that the activity (and energy consumption) is not necessarily reduced, but rather shifted to another time period. Dynamic pricing is a new metered load management approach that uses price signals to induce customers to reduce energy use at specific times of the day, typically when energy is the most expensive to procure.

This chapter will focus on energy efficiency and conservation, with special emphasis on end-uses associated with consumer demand and their connection to system adequacy. The chapter will also consider the relationship of efficiency and conservation strategies to load management strategies, especially the newest strategy of dynamic pricing, as well as their role in other energy arenas such as renewable and DG. Dynamic pricing as a whole will be the subject of the next chapter.

PROGRAM POLICY AND EXPENDITURE TRENDS

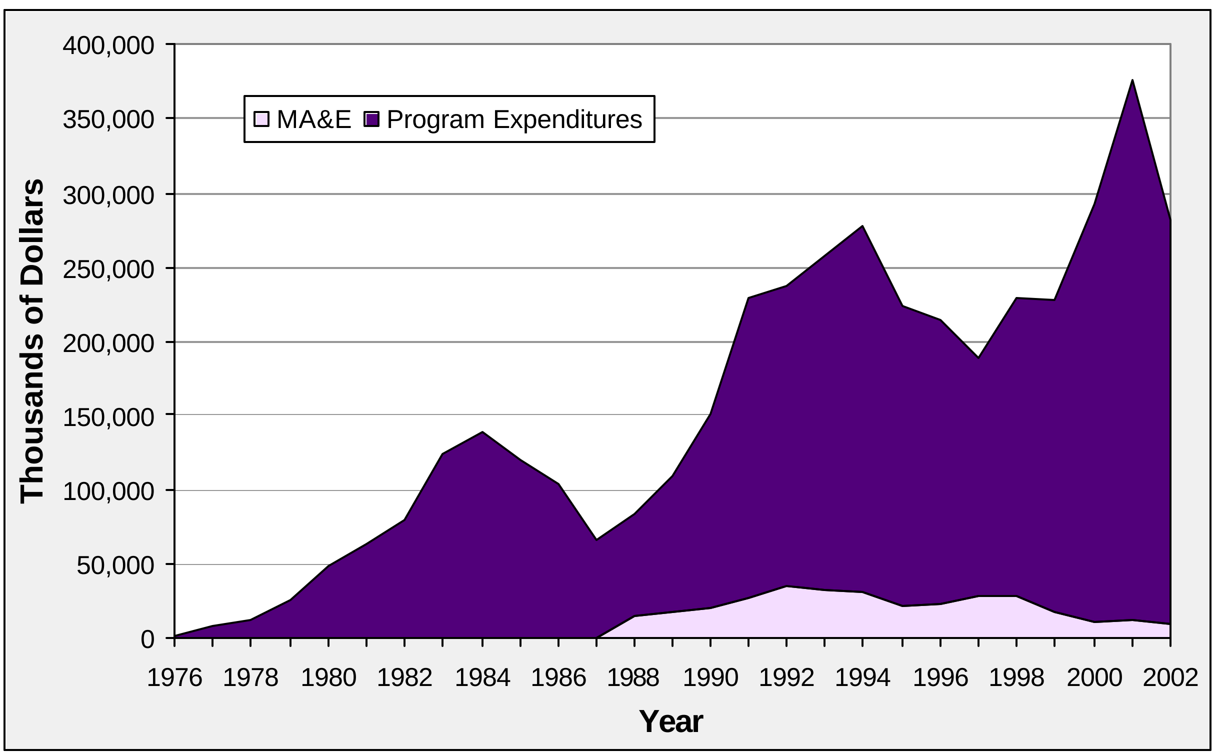
Efficiency programs reduce the energy dependence of California’s economy, make businesses more competitive, and allow consumers to save money and live comfortably. By law, each utility customer pays a small public goods charge (PGC) to support public programs for energy efficiency, low-income services, renewable energy, and energy-related research and development. Legislation signed in September 2000 (Senate Bill 995, R. Wright, Chapter 1051, Statutes of 2000) extended the public purpose funding from 2002 through December 31, 2011, authorizing $5 billion over that time period for the four program areas. Energy efficiency programs receive the largest portion of the funds, approximately $2.3 billion. In contrast to the other programs, energy efficiency programs must meet cost-effectiveness criteria. Separate legislation (Assembly Bill 1002,

R. Wright, Chapter 932, Statutes of 2000) imposed the natural gas surcharge indefinitely for low-income assistance, cost-effective energy efficiency and conservation activities, and public interest research and development. Spending on natural gas efficiency has averaged between $30-40 million in recent years.

Approximately 1.0 percent of each investor-owned utility customer's electric bill and 0.7 percent of each natural gas bill supports the energy efficiency public benefit programs. Publicly-owned utility funding is determined by a formula that calculates the lowest expenditure level of the three largest investor-owned utilities as a percent of total 1994 revenue. In 2002 this number was 3.6 percent, but will be adjusted annually based on sales growth and inflation.

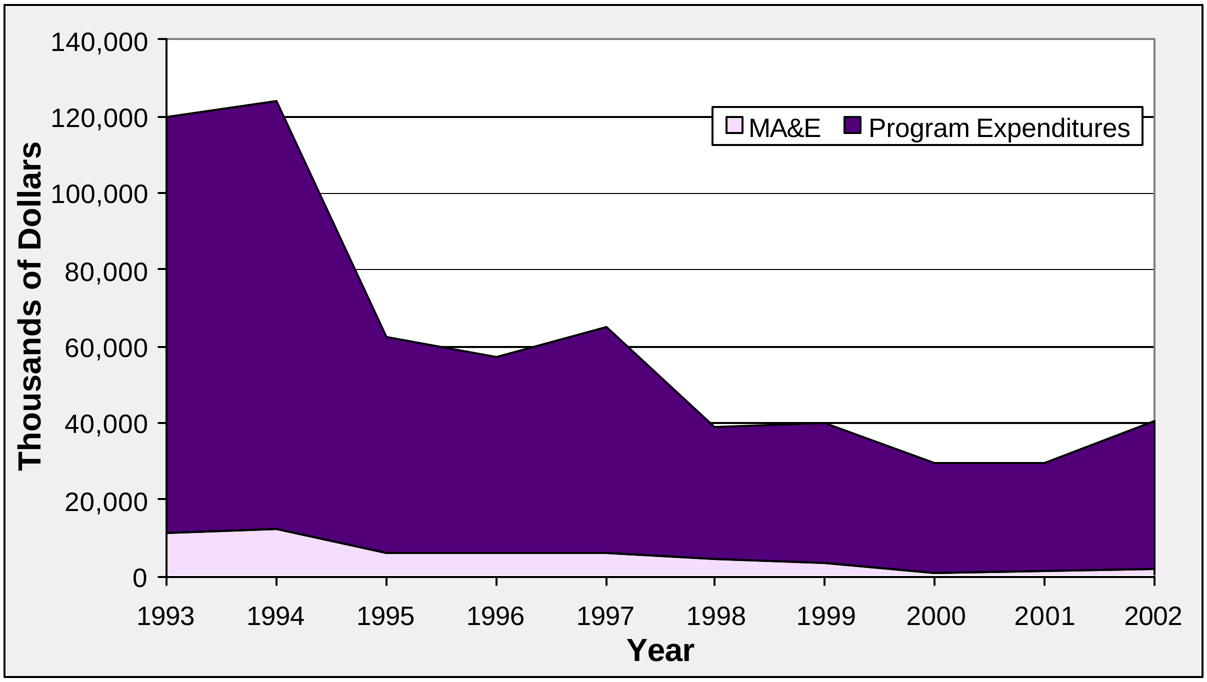
Expenditures for energy efficiency exhibit a long history of expansion and contraction that is related to changing fuel prices and a combination of regulatory and legislative policy decisions.[14] The last decade alone is characterized by three shifts in policy emphasis, which in turn altered key program directions. **Figure 3-1 and Figure 3-2** illustrate annual expenditures for energy efficiency programs and evaluation for both electricity and natural gas. Expenditures reported by investor-owned utilities, municipal utilities, and public agencies are included. 2000-2002 reflect expenditures from legislative appropriations for peak load reduction programs.

Figure 3-1
Electric Efficiency Program and Evaluation Expenditure Trends



Spending on electricity efficiency programs and evaluation has varied considerably as policy objectives change.
Source: California Energy Commission and Annual Earnings Assessment Proceeding Filings

Figure 3-2
Natural Gas Efficiency Program and Evaluation Expenditure Trends[15]



Annual spending on natural gas efficiency programs and evaluation has declined over the past decade.
Source: California Energy Commission and Xenergy

Pre-Restructuring Period

Through the mid-1990s, California's energy efficiency and conservation programs were part of a biennial resource planning effort conducted jointly by the CPUC and Energy Commission. The process adopted planning area demand forecasts and determined the need for resource additions to match these levels of demand. Spending on energy efficiency and other DSM activities were recognized as "viable cost-effective alternatives to supply-side energy generation projects."[16] Funding for conservation and efficiency programs reached its zenith in 1994, only to decline again with the growing uncertainty surrounding restructuring. Primary program strategies centered on customer assistance through audits and financial incentives in the form of rebates or direct payments. Evaluation activities measured energy savings impacts of resource acquisition programs and their persistence over time.

Restructuring Period

With the passage of Assembly Bill 1890 (Peace, Chapter 854, Statutes of 1996), the focus shifted to achieving longer-term energy savings that would be sustainable after public subsidies ended. AB 1890 authorized a minimum of $228 million a year for energy efficiency programs administered by the investor-owned utilities and overseen by the CPUC, and temporarily, the California Board for Energy Efficiency, which served as a public advisory board.

Significant program changes occurred in the restructuring period. Policy focus began to shift toward creating "well-functioning markets" in which consumers and producers could make informed choices about energy-using equipment and services. Utilities were directed to move to statewide "market transformation" programs with consistent program designs and coordinated implementation efforts. Evaluation moved away from documenting energy savings to measuring market effects.

Post-Restructuring Period

2000 marked a major turning point in public benefit programs. Increasing concern about wholesale electric prices and reliability prompted a change in 2001 back toward resource acquisition-style programs in order to quickly reduce electricity consumption and achieve load reductions. Unspent funds from previous years augmented funding to levels not seen since the early 1990s. This period will be covered in greater detail in the "Energy Crisis Initiatives, Achievements and Lessons" section of this chapter.

The energy efficiency public benefit programs are undergoing a further re-examination in the CPUC's rulemaking R.01-08-028. Several new policy trends have emerged in this proceeding:

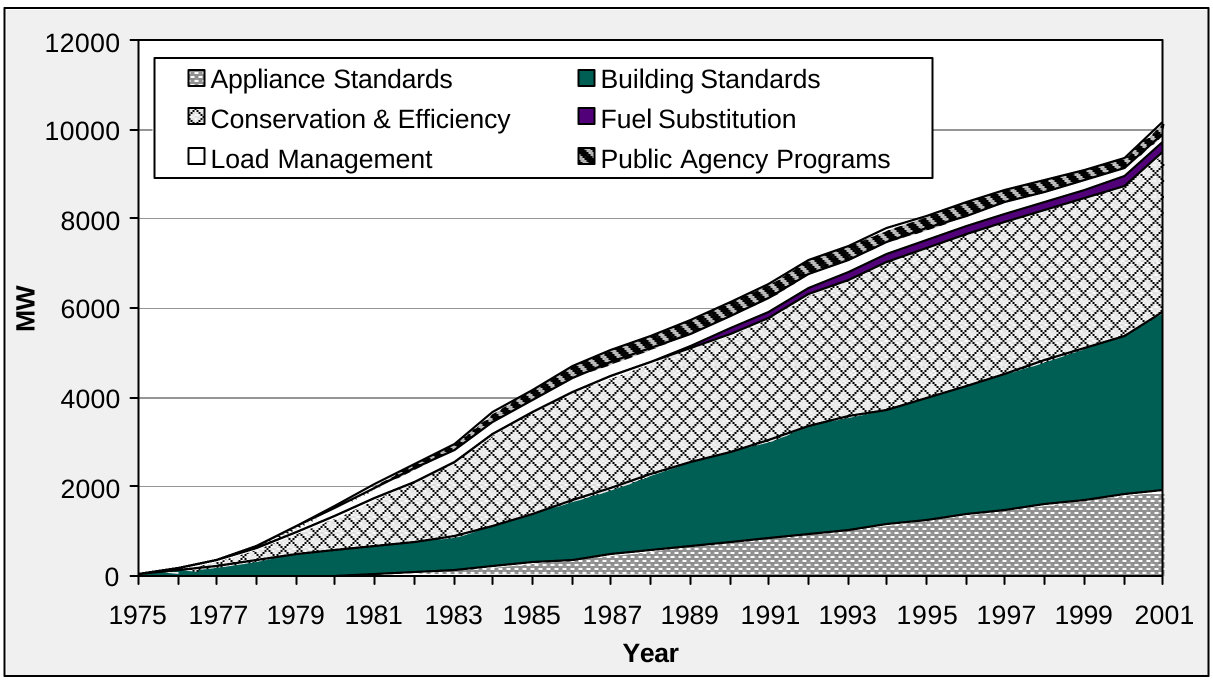
- The CPUC opened the door to local government initiatives to leverage local organizational knowledge in meeting the needs of small business and particular communities (e.g. Spanish-speaking, rural) on an equity basis. Twenty percent of PGC funds were set aside for "third-party" proposals from private-for-profit, non-profit, and public entities to provide local programs.
- Ongoing funding supports a statewide consumer marketing and outreach campaign, modeled on *Flex Your Power*, but aimed at energy efficiency.
- The CPUC committed to developing policy direction on the issue of future program administration as part of this rulemaking.
- A joint government/utility pilot project will combine energy efficiency with other DSM strategies to reduce pressure on a key transmission corridor in San Francisco.
- The California Legislature restored the energy efficiency procurement responsibilities to the investor-owned utilities effective January 1, 2003, marking a return to the integrated resource planning of the pre-restructuring period. Further impacts that this transition may have on energy efficiency program policy will be discussed later in this chapter in the "Challenges to Achieving Reliable Energy Efficiency" section.

Information on the energy efficiency programs currently offered in California is found in ***Appendix B*** of this report. Programs of the investor-owned utilities, "third-parties," municipal utilities, local governments and state agencies are described along with their funding levels and impacts. Several examples of collaborative programs are also included.

SAVINGS TRENDS

California's efficiency initiatives have made a substantial contribution to slowing the growth of electricity and natural gas use over the past 26 years. As shown in **Figure 3-3**, the cumulative effects of all of California's electric efficiency programs, including municipal utility and public agency programs, and standards are more than 10,000 MW and 35,000 GWh in savings through 2001. These savings are equivalent to the output of 20 500-MW power plants. Program savings, which account for half of the cumulative effects, are most dramatic in residential and commercial buildings.

Figure 3-3
MW Savings from Programs Begun Prior to 2001

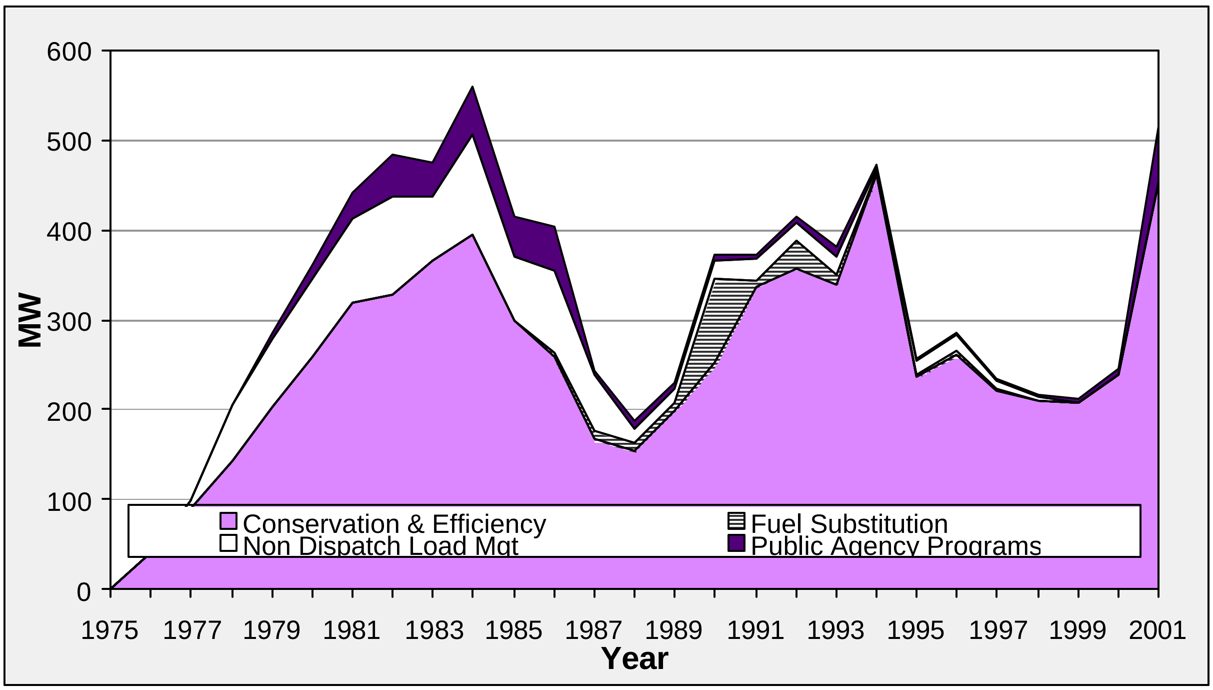


Efficiency programs and standards have contributed equally to achieving significant peak demand savings over the past 26 years.
Source: California Energy Commission

The pattern of year-to-year electricity savings from utility programs has generally tracked expenditure levels over the past 26 years. This point is illustrated showing incremental peak savings using nominal dollars in **Figure 3-4**. The highest level of savings attributed to electricity conservation and efficiency programs historically occurred in 1994, the year of highest funding. The downturn of spending in both the late 1980s and 1990s is apparent. Augmented funding in 2000, however, triggered a new incremental high of 453 MW.[17]

Energy savings accumulate over the useful life of a particular piece of equipment or conservation practice is in place. Using first-year savings (savings achieved by programs in that year) as a measure, energy savings of 1,800 GWh were achieved in 1994, but more typically are 1,000 GWh annually. Public benefit programs have added more than 200 MW annually toward peak reduction in recent years.

Figure 3-4
Incremental MW Impacts from Programs Begun Prior to 2001



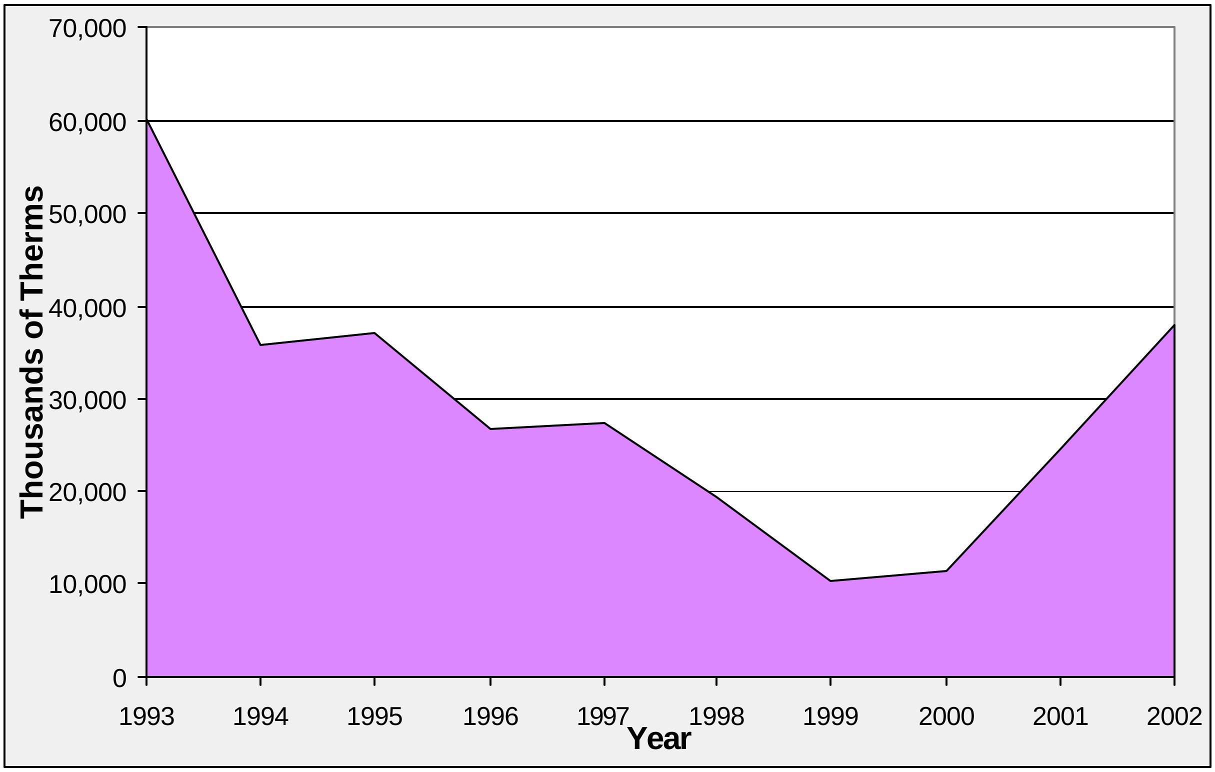
Peak demand savings vary over time as policy direction and program expenditures change.
Source: California Energy Commission

As much as 80 percent of these savings come from the nonresidential sector. The residential proportion of both energy and peak program savings has been increasing faster since 1999. New construction program savings have remained steady as a share of first-year peak demand savings, but are declining as a share of first-year electric energy savings in recent years.

The building and appliance standards have saved more than $36 billion in electricity and natural gas costs, even accounting for the costs of purchasing the more energy efficient buildings and appliances. By 2013 the standards will save Californians an additional $43 billion in utility costs, producing a net savings to customers of $ 79 billion.[18] Every dollar saved through energy efficiency is a dollar that can be spent elsewhere.

Natural gas efficiency programs have saved two billion therms (BTh) since 1978. Incremental natural gas savings over the past decade are shown in **Figure 3-5**.

Figure 3-5
Incremental Natural Gas Savings from 1993-2002 Programs



Natural gas savings declined as program expenditures declined in the 1990s, but increased as price volatility began in 2000.
Source: California Energy Commission

The pattern of energy savings for natural gas generally follows expenditure levels, similarl to that for electricity. Tightening of building and appliance standards as well as technical constraints on increased gas efficiency has also dampened program effects in recent years. Part of the decline may also be due to changes in reporting requirements. First-year savings averaged around 79 million therms over the period 1976-2000. Nonresidential (commercial and industrial) sectors accounted for an average of 60 percent of natural gas savings historically, but represented closer to 72 percent of savings in recent years. Residential and new construction programs accounted for an average of 35-40 percent of savings.

Improvements in energy efficiency will ultimately reduce the amount of energy that is required from fossil-fuel generating plants. Reducing generation from such facilities will lead to a concurrent reduction in power plant emissions, such as NO_x, sulfur dioxide

(SO_2), and carbon dioxide (CO_2), thus benefiting all Californians with a cleaner, healthier environment. By decreasing the amount of electricity required, energy efficiency also reduces the need for new natural gas-fired generation capacity. Given the recent volatility in natural gas supply and prices, this is an important benefit for California's consumers

ENERGY CRISIS INITIATIVES, ACHIEVEMENTS AND LESSONS LEARNED

The summer of 2000 was marked by increases in the wholesale price of power and isolated supply shortfalls. By the winter of 2001, constrained electricity supplies forced rolling blackouts throughout the state. These circumstances led to renewed interest in demand-side programs as a resource that could help alleviate electric system adequacy problems. California government authorities used executive, legislative, and regulatory policy responses centering on energy efficiency to respond to the reliability crisis.[19]

Initiatives

Early in 2001, Governor Davis's executive order declaring a State of Emergency triggered a series of state responses, set energy and peak reduction goals for the state overall, and established minimum peak reduction objectives for state buildings. Later executive orders authorized and funded the "20/20" program, which offered a 20 percent credit for investor-owned utility electric customers who reduced their summer month bills compared to the previous year by 20 percent, and *Flex Your Power*, a statewide mass media and outreach campaign managed by the State and Consumer Services Agency.

During 2000-2001, the Legislature passed AB 970, SB X1 5 and AB X1 29 setting policy and allocating an additional $1.1 billion for demand-side programs. Energy efficiency programs initiated by the Energy Commission, other state agencies, municipal utilities, investor-owned utilities, local governments, and other non-utility parties received about $850 million of the total. Most of these programs emphasized lowering peak demand.

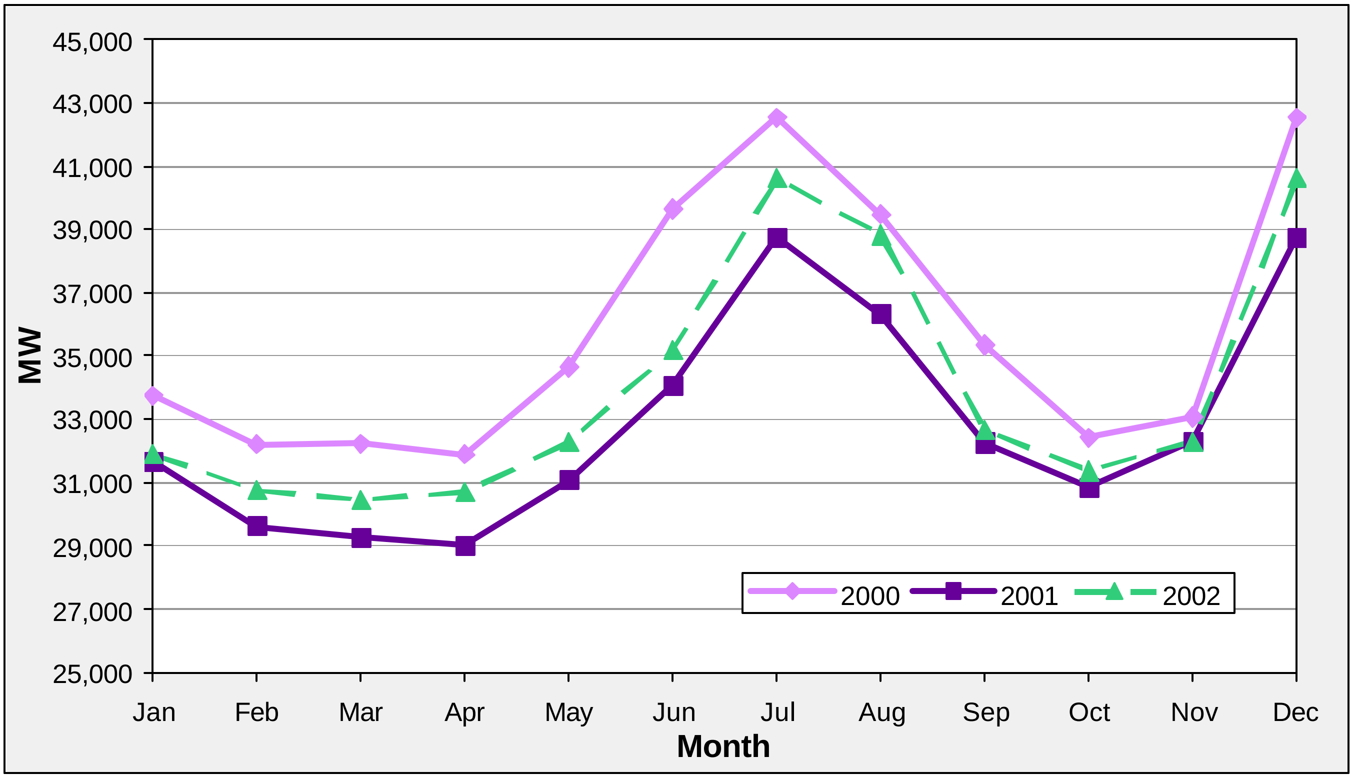
Parallel to actions by the governor and Legislature, the CPUC used its regulatory authority to adopt a "Summer Initiative" in July 2000 as a "rapid-response procedure." Further regulatory action in early 2001 authorized the investor-owned utilities to redesign their programs toward immediate energy savings and demand reduction, and away from longer-term market transformation activities.

Achievements

California's efforts in 2001 paid off when the state averted large-scale summer blackouts and widespread economic losses. California's experience has received nationwide attention as a model for the power of multiple entities responding to a problem together. Investor-owned utilities, municipal utilities, state agencies, local governments, and other third-parties delivered energy efficiency services to California consumers through as many as 218 distinct programs.[20]

Relative to 2000, peak demand in 2001was down an average of 10.4 percent during the critical months of June to September, according to data adjusted for weather and growth from the CA ISO[21] control area. Annual adjusted energy consumption in the CA ISO dropped by 6.7 percent in 2001 compared to 2000. **Figure 3-6** compares peak demand for 2000, 2001, and 2002. Peak demand reduction for 2002 remains approximately 50 percent of peak demand reduction in 2000.

Figure 3-6
Comparison of Monthly Peak Demand for 2000-2002



California continues to use 50 percent less electricity on peak in 2002 than in 2000.
Source: California Independent System Operator

A recent study, ***California Summary Study of 2001 Energy Efficiency Programs***, summarizes energy savings resulting from all of the programs that were put in place in response to the crisis.[22]

- Program expenditures of approximately $893 million yielded estimated first-year savings of over 4.76 million MWh and reduced demand by 3,389 MW at a first-year cost of $0.19 per kilowatt-hour (kWh).
- The overall statewide cost becomes $0.03 per kWh saved over the useful lifetime of the equipment and hardware installed in 2001.[23]

Lessons Learned

Despite widespread national reliability concerns during 2000-2001, few states used energy efficiency as a response strategy. Twenty-one states reported reliability problems, but most relied solely on load management and demand response.[24] California's programs proved to be the most notable exception.

With so many different entities administering over 200 programs, the availability, quality, and consistency of program documentation varied considerably. Differing assumptions and conventions made it difficult to compare cost-effectiveness across programs.

California's recent energy crisis offers several specific examples of system adequacy benefits gained through energy efficiency and conservation strategies. Key findings from consumer research conducted in 2001 and 2002 by Dr. Loren Lutzenhiser and others reveal:[25]

- Unexpected consumer demand elasticity added flexibility to the energy market.
- Changes in consumption for 2001 compared to 2000 were not weather-driven, but resulted from actual changes in behavior patterns.
- Changes in behavior rather than efficiency improvements accounted for most of the 2001 reduction.
- Consumer willingness to turn off air conditioners largely contributed to lower consumption.
- The reductions in consumption were not evenly spread throughout the population; all households did not contribute an equal amount of reduction.
- Persistence of some behavioral changes continued long after the immediate crisis had passed.
- Behavioral changes were often not induced by prices, but by civic concerns and altruistic motives. For example, some people shifted energy use to off-peak periods, even though it meant no savings on their bills.
- Rapid deployment and implementation of energy efficiency efforts by a variety of entities proved both possible and useful in a crisis situation.

A more complete discussion of consumer conservation behavior during the energy crisis is found in Appendix A of this report.

ADDITIONAL ACHIEVABLE ENERGY SAVINGS

Given the success of the combined state response in lowering consumption and peak demand in 2000-2001 and California's status as the state with the lowest per capita electricity consumption, it may seem as though achieving anything more through additional savings would be difficult. But research shows that California has much more potential for both electric and gas savings that could cost-effectively be achieved through existing technology, emerging technologies, and conservation behavior. The additional contribution of each of these three types of potential will be described in turn.

Potential Energy Savings Available through Existing Technology

The remaining potential savings achievable with commercially available technologies are far from exhausted. Despite its cost-effectiveness, energy-efficiency equipment is not always purchased for a variety of reasons, including among others, little knowledge of the product, uncertainty over equipment performance or higher initial cost for the product compared to less-efficient models.

Potential Achievable Electricity Savings

Staff analysis and a leading research organization concur that a doubling of current energy efficiency expenditures statewide could reduce projected peak load by 1,700 to 1,800 MW in 10 years time – a 12 percent reduction in projected demand growth. In the report *California's Secret Energy Surplus: The Potential for Energy Efficiency*,[26] Xenergy, Inc. evaluated both technically and economically feasible measures for reducing California's electricity use and then factored in estimates of customer adoption rates under different program scenarios. The authors considered only measures that could be substituted for, or applied to, already-installed technologies on a retrofit basis. Neither emerging technologies nor savings that might be achieved through an integrated redesign of a building's existing energy-using systems were considered for this study.

The authors evaluated the potential for energy savings under three future program investment scenarios that modified the economic potential with realistic expectations of customer adoption:

- Continued current energy efficiency funding (included in baseline demand forecast),

- A 100 percent increase in current funding (the “advanced efficiency scenario”), and
- A 400 percent increase in current funding (the “maximum efficiency scenario”). “Maximum achievable potential” is defined as the amount of economic potential that could be achieved over time under the most aggressive program scenario possible.

Table 3-1 summarizes the results for these scenarios looking forward 10 years from 2001. For the Maximum Efficiency Scenario, Xenergy found the potential for 5,900 MW in savings in 10 year’s time. Given that peak demand in the state is projected to increase by approximately 10,000 MW by 2011, implementation of all cost-effective program potential (as represented by the Maximum Efficiency Scenario) would cut growth in peak demand by 50 percent.

Equally impressive are the estimated ancillary benefits from these investments in energy efficiency. The report indicates that increasing funding to energy efficiency programs would not only reduce consumption, but also capture billions of dollars in additional savings. By doubling the amount spent on efficiency programs, the state could save over $15 billion on electricity costs, for a net savings of $8.6 billion. If all of the 10-year achievable potential were captured, savings would exceed $20 billion, for net savings of $11.9 billion.

Table 3-1
Summary of 10-Year Net Achievable Energy Efficiency Potential (2002-2011)

	Business as Usual Scenario	Advanced Efficiency Scenario	Maximum Efficiency Scenario
Program Costs	$2.003 Billion	$4.663 Billion	$8.196 Billion
Participant Costs	$2.052 Billion	$2.646 Billion	$3.111 Billion
Total Costs	$4.055 Billion	$7.309 Billion	$11.307 Billion
Estimated Benefits	$9.604 Billion	$15.949 Billion	$23.203 Billion
Net Savings	$5.549 Billion	$8.640 Billion	$11.896 Billion
GWh Savings	9,637	19,445	30,090
Net MW Savings	1,788	3,480	5,902

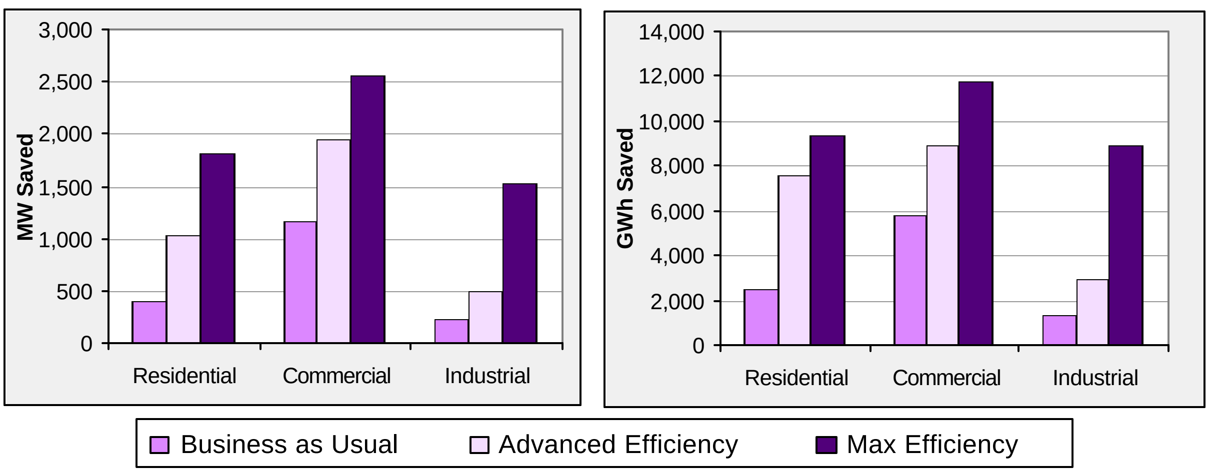
Increased funding for energy efficiency could lead to significant consumption and peak demand savings over a ten-year period.

Note: Present value of benefits over 20-year normalized measure lives for 10 program years (2002-2011), nominal discount rate = 3 percent, GWh and MW savings are cumulative through 2011.
Source: Xenergy, 2002

Net achievable potential savings by customer sector for the period 2002-2011 are presented in **Figure 3-7**. The greatest economic potential for electricity savings lies with the commercial sector, the least with the industrial sector, and the residential sector lies between the two. Averaged across all three sectors, new construction accounts for roughly 10 to 15 percent of the total estimated achievable savings potential.

These findings point to a significant level of achievable and cost-effective potential for electric energy-efficiency savings over and above the Business-as-Usual approach, which holds current funding levels constant, as in the 2003 demand forecast. Capturing this additional achievable potential would require an increase in existing PGC funding levels for energy efficiency programs, effective program design, corrective evaluative feedback, and widespread customer participation. **Figure 3-7** indicates that a large portion of the commercial sector cost-effective peak demand savings could be achieved with a doubling of current funding.

Figure 3-7
Net Achievable Electricity Savings by Sector



Most of the economically achievable energy and peak demand savings are in the commercial sector.
Source: Xenergy, 2002

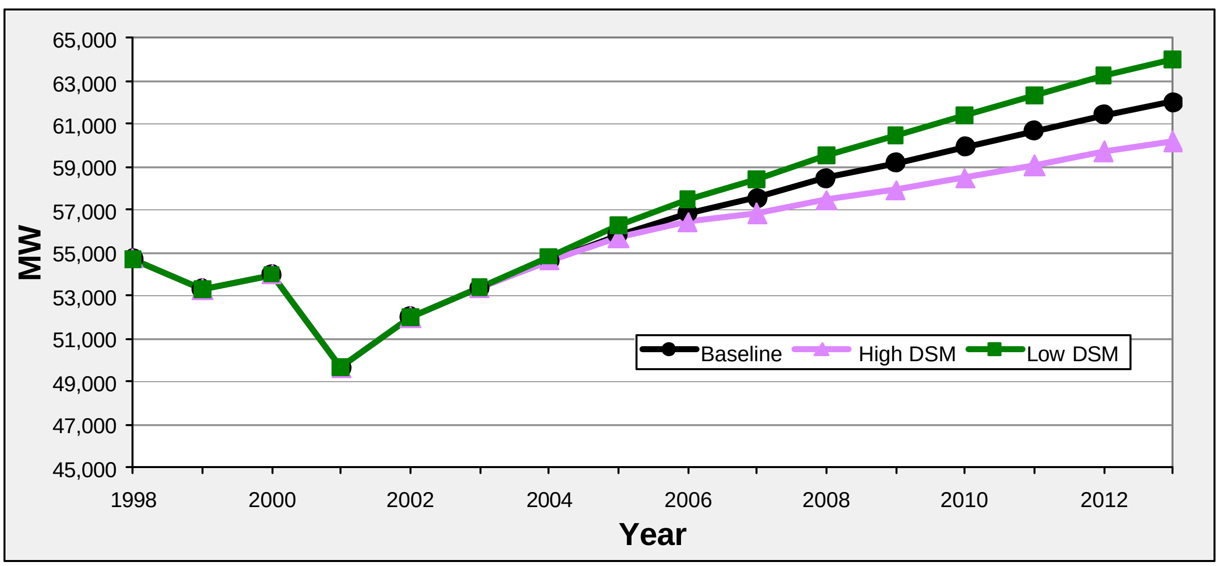
The Energy Commission staff used the results of this study in preparing its energy demand forecast, specifically in the evaluation of alternative DSM scenarios. The baseline forecasts for both electricity and natural gas demand embed current levels of funding for utility energy efficiency programs going forward. To estimate the effects on demand of increased investment in energy efficiency, the Energy Commission used scenarios developed as part of a series of more detailed studies of energy efficiency potential in California underlying the Energy Foundation study.[27] **Figure 3-8** illustrates these two scenarios compared to the baseline forecast.

The High DSM Scenario estimates the effect on demand of doubling the amount of energy efficiency spending statewide beginning in 2004 and continuing through 2013. The Commission selected a doubling scenario for two reasons. Analysis of historic efficiency spending patterns shows that gradual increases in funding is likely to yield more energy savings and be more sustainable.[28] A 100 percent increase in funding will capture a large majority of the cost-effective savings available in the commercial and residential sectors as shown in **Figure 3-7**.

Increasing PGC spending on energy efficiency to $572 million per year from a baseline of $285 million per year (based on average electricity and natural gas spending 1996-2000) reduces demand by about 1,800 MW in 2013. This would represent a 3 percent reduction in electricity peak demand per capita over the ten years. Eliminating all spending on energy efficiency after 2003 would increase demand in 2013 by 1,900 MW. System impacts and the per capita use consequences from these DSM scenarios are discussed in Chapter 3 of the ***Electricity and Natural Gas Assessment***

The Energy Commission believes that an increase in energy efficiency funding over and above the current public benefit funding level is warranted. The DSM scenarios seem to show cost-effective potential even if shortfalls in consumer acceptance of efficiency measures are as high as 20 percent. The Energy Commission has not yet determined how large a funding increase is appropriate state policy, but the initial level should be at a minimum in the range of the 60-70 percent increases proposed by the investor-owned utilities in their procurement plans.

Figure 3-8
High and Low DSM Scenarios Forecasted in Peak



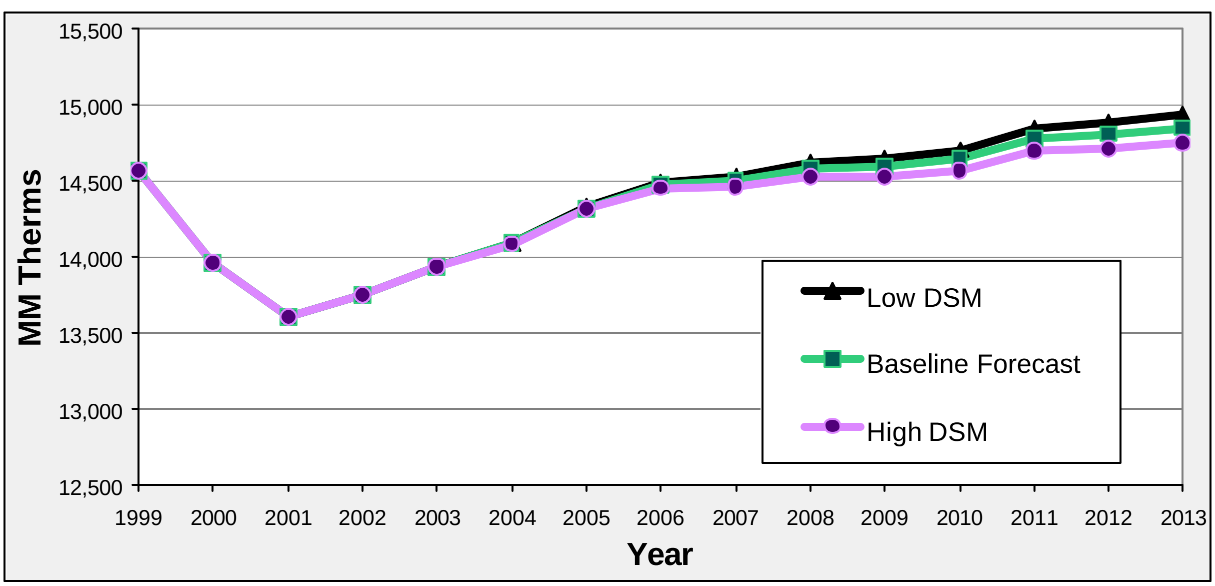
Peak demand in 2013 could be reduced by 3 percent with a 100 percent increase in energy efficiency funding.
Source: California Energy Demand Forecast, 2003

Selecting the appropriate funding level must also take into consideration how quickly programs can be geared up and whether other already-paid-for resources might be displaced. As part of stabilizing the electricity market, utilities have entered into long-term contracts that cover most of the operating hours. In addition, the Renewable Portfolio Standard will be adding new generation. Since customers are already required to pay for these resources, energy efficiency must be assessed as part of a balanced portfolio. As explained later in this chapter, new administrative and evaluation rules may be put into place within the next two years. Therefore, a strategy of “gearing up” appears to be a sound policy direction. This would mean committing to the concept of putting energy efficiency first, resolving program delivery issues, and embarking on a moderate expansion of energy efficiency funding.

Potential Achievable Natural Gas Savings

A similar set of scenarios estimated the effect on demand for natural gas of an increased investment in energy efficiency, as shown in **Figure 3-9**. The data available for analyzing natural gas end-uses is less developed than for electricity, therefore, more uncertainty surrounds these potential numbers. The natural gas High DSM scenario estimates the effects of roughly doubling spending on energy efficiency programs for the residential and commercial sectors. Increasing spending on natural gas efficiency to $71 million per year from $31 million per year (based on average spending 1999-2000) reduces demand by about 103 million therms in 2013. No data were available on industrial energy efficiency potential, so industrial demand is unchanged in the DSM scenarios. Cost savings would increase from an estimated savings of $143 million under current funding to $308 million. The DSM scenarios have a much smaller effect on the demand for natural gas.

Figure 3-9
High and Low DSM Scenarios Forecasted for Natural Gas



Doubling funding for natural gas efficiency programs could lower gas consumption by 0.7 percent.
Source: California Energy Demand Forecast, 2003

Additional Savings Available from Adoption of Emerging Technologies

The potential for future energy savings, particularly peak demand savings, would exceed current projections if emerging technologies were considered. Research within the Public Interest Energy Research program at the Energy Commission is fostering development of several new technologies including:

- Residential reflective roofing products;
- AC equipment better optimized for homes in California's hot dry climates;
- Commercial AC equipment that provides sufficient outdoor ventilation to maintain healthy indoor air more effectively, particularly in areas of high occupancy, such as school classrooms;
- Industrial process technologies which reduce electricity use and have wide applicability across California; and
- Technologies that will change access to electricity, namely electricity storage technologies, and highly efficient and clean distributed generation technologies.

Equally important, public interest research is expanding the opportunities to reduce energy use and peak demand by moving beyond technologies to developing new products and knowledge that could support more efficient design, construction, and operational practices.

Possibilities include:

- New equipment design guidelines;
- Construction protocols for quality construction practices; and
- Diagnostic tools and commissioning processes for already installed and operating equipment.

Future Energy Savings Available from Conservation Behavior

Energy efficiency depends upon consumers' abilities to identify the potential for savings, to select appropriate technologies, and to install and use them correctly. Studies of energy use behavior change during the 2001 crisis showed significant household conservation action, including efficiency investment. Based on studies by Lawrence Berkeley National Laboratory and the Energy Commission, it appears that 25-30 percent of the customer load reductions observed in 2001 were the result of energy efficient investment and on-site generation gains. Behavior changes contributed the other 70-75 percent of the observed load reductions in 2001.[29]

Follow-up surveys by Dr. Loren Lutzenhiser in the fall of 2002 suggest that residential sector conservation is continuing and that there is potential for additional consumer actions in the future. A complete discussion is found in Appendix A of this report. In terms of continuing conservation, findings include:

- Voluntary conservation continued to produce energy savings, with about one half of the 2001 crisis savings persisting in 2002, controlling for differences in weather between the two years.
- A majority of households reported a variety of continuing conservation actions in 2002. These ranged from retrofits to building shells, new appliance purchases, turning off lights and appliances, and continued non-use of AC.
- While some consumers reported a decline in their conservation actions, others reported new efficiency choices and the adoption of new conservation behaviors in 2002.
- The patterns of continued conservation behavior were segmented, with different consumer groups (e.g., homeowners, renters, hard-to-reach segments) continuing with different sorts of actions.
- Consumers reported continuing concerns about the California energy situation, a willingness to continue conserving energy, and a seriousness about their commitments. A large majority also supported continued action by government agencies and utilities to encourage and support energy conservation by households, businesses, and governments.

In terms of the potential for additional future savings from conservation and efficiency behavior, the studies suggest that:

- Consumers are clearly willing to respond positively to credible requests for demand savings in crisis or system emergency conditions. Many may have remembered earlier habits and patterns of energy savings that, even if subsequently stopped, could be readily recalled in an emergency situation.
- Nearly 3/4 of the households reporting having purchased a new appliance during the past two years said that they took energy efficiency into account in making their choices.
- In terms of measured energy savings from residential conservation actions taken during 2001, the most significant individual impacts were associated with building shell improvements and voluntarily not using AC.[30] Building improvements, improved cooling efficiency (higher efficiency AC, non-air conditioner cooling), and improved shell/air conditioner management (both behavioral and automated) would seem to offer proven targets for future energy and demand savings.
- Relatively low levels of program and incentive recognition by consumers in both the 2001 and 2002 surveys suggest opportunities for better informational efforts in support of efficiency and conservation goals.

CHALLENGES TO ACHIEVING RELIABLE ENERGY EFFICIENCY

Energy efficiency adds significant value to the energy system in California. It reduces load growth across the system. Energy efficient products and technologies provide tools with which consumers can respond to price volatility. In times of emergencies, short-term energy efficiency efforts can avert energy system reliability problems. Achieving energy efficiency's full potential for system benefits, however, will require addressing two significant challenges in the near term: (1) improving the certainty of energy efficiency and conservation, and (2) delivering energy efficiency more effectively.

Improving the Certainty of Energy Efficiency and Conservation

Energy efficiency has two major risk characteristics that are perceived to compromise its contributions to electric system reliability: 1) the impacts of efficiency are neither readily predictable nor easily quantifiable; and 2) energy-saving measures cannot be called upon as resources in real time. In order to reliably count on energy efficiency as part of a procurement portfolio, these two risk factors must be managed. The remainder of this section will describe ways in which evaluation, social science research, data collection, and creating synergies between efficiency and dynamic pricing programs could reduce the risk characteristics of energy efficiency and conservation.

Predicting and Quantifying Efficiency Impacts

California is a leader in the nation in terms of energy efficiency policies and achievements. We have a public benefits funding system. We have strong complementary strategies between public benefit programs and the building and appliance efficiency standards. We have an excellent track record in measuring demand and estimating load growth. To utilize energy efficiency as a component of a procurement portfolio, however, will require greater assurances that the savings actually will be delivered. Energy efficiency impacts used in integrated resource plans need to be unbiased, realistic estimates of expected impacts. Efficiency impacts could be made more predictable and more readily quantifiable through three risk-reducing strategies: rigorous evaluation, social science research, and data collection.

Reducing Risk through Rigorous Evaluation. A return to a more vigorous and defensible evaluation framework will be necessary, if energy efficiency is to be valued as a reliable resource. Energy efficiency, demand response, and distributed generation require measurement and evaluation activities that are unlike the instrumentation available to measure conventional generation resources. Evaluations should be used to estimate the peak and annual energy savings (load impacts) of programs and to estimate the uncertainty range around these estimates. Monitoring, measurement, and verification of installations using standardized protocols will be critical. Standard measures of performance, such as either the Energy Use Index or unit cost and cost savings, would enable comparisons across programs. Improved methods for measuring attribution of savings to programs would assist in fulfilling program goals while avoiding double counting of savings. To accomplish this, the declining trend for expenditures on measurement and evaluation must be reversed. A first step in this direction is the designation of a percentage of procurement funding for measurement by the investor-owned utilities.

Reliance upon energy efficiency, demand response, and distributed generation as substitutes for conventional generation requires a commitment to intensive measurement and evaluation. Efforts must be made to determine what measures consumers are willing to choose and the patterns of impacts from these choices. Verifying not only what happened, but how those measures or changes in consumer behavior translate into load impacts by time period will be important. Since dynamic pricing is likely to change the time patterns of electricity use, it will change the baseline load shapes against which the impacts of energy efficiency programs are measured.

Cost-effectiveness testing historically relies on static point estimates of predicted program results. Cost-effective programs should score at least 1.0; theoretically, the higher the number the more cost-effective the program. The tests, however, do not account for major uncertainties in the actual outcomes of the investments. By appearing more precise than they actually are, point estimates can discriminate against programs with riskier, but potentially better results.

Cost-effectiveness is also a critical component in assessing efficiency and demand reduction resources for procurement. The CPUC has initiated a study to determine the appropriate avoided costs in an uncertain market environment. Accurate avoided cost values are necessary to avoid over- or under-investing in efficiency, distributed generation, and demand reduction resources. Additional work is proceeding under CPUC auspices to develop a new program evaluation framework designed to increase the reliability of program savings impacts for use in resource planning and increase the quality of feedback from evaluation to program administrators, utilities, and the state energy agencies.

New portfolio analysis tools will be needed to estimate the contribution of efficiency resources to the procurement portfolio and compare their cost to other supply and demand options. Such tools would enable procurement planners to judge the effect of marginal resource additions on grid reliability and overall system costs. The investor-owned utilities have begun to explicitly consider risk in their resource planning.

Reducing Risk through Social Science Research. The field of behavioral economics links economics with sociology, anthropology, psychology and other behavioral sciences in the study of decision-making. If energy efficiency is to be valued as a reliable resource, the application of this field to energy efficiency is necessary.

Behavioral economics has been stimulated by a growing body of evidence that the standard economic model of rational behavior has serious shortcomings as a model of individual decision-making. For example, many key constraints that keep consumers from making energy-efficient choices are related more to inadequate information and trust issues than a higher initial cost.

Behavioral economics and other social science approaches offer the promise of a better understanding of the nature of energy-related decision-making as well as the nature and magnitude of the perceived under-adoption of energy-efficient practices and technologies. Savings risks being reduced or lost if the customer cannot maintain the equipment or stay motivated to continue the behavior. Understanding what types of media, information materials, or other messages resonate with consumers could lead to higher persistence of load impacts.

Reducing Risk through Data Collection. One of the most valuable lessons of the last thirty years is that analyzing how people use energy and how energy use changes over time can yield valuable policy insights. Demand and load forecasts provide the basis for energy policy decisions and financial resource allocations. Energy load forecasts determine future energy supply-demand balances. Demand analysis is used to evaluate conservation potential, develop energy efficiency policies and programs, and to estimate the amount of conservation that can be relied upon when supplies are short. Forecast and demand analysis tools evaluate consumer reactions to new time-varying rate designs.

The complexity of the new energy market is imposing additional requirements for data. Energy Commission assessments will be the basis for resource adequacy planning and procurement activities. The Commission recognizes that the SB 1389 (Statutes of 2002) requirement for a data management system to support integrated resource planning must be carefully considered, but several analytical changes seem certain. Shorter time horizons for forecasts are important. Forecasts for regions smaller than utility planning areas are needed, particularly for targeted energy efficiency in transmission-deficient areas. Forecasts could be improved by a more complete understanding of the contribution of various end-uses to historical growth in annual energy consumption and peak load, particularly in the commercial sector. Data requirements for these new types of analyses include:

- Load data from utilities and other market providers;
- Site-specific interval meter data;
- End-use characteristics in all market sectors;
- Saturation data for energy-using equipment;
- Market tracking data to estimate penetration of efficient technologies;
- Consumer behavior;
- Equipment operational patterns and practices;
- Geographic and seasonal detail for supply-demand congestion assessments; and
- Natural gas storage data plus flow and price data for strategic points (e.g., Topock).

Making Energy Efficiency More Responsive in Real Time

Historical achievements of past energy efficiency programs and current market data suggest that a large fraction of California's anticipated load growth over the next decade could be displaced through a combination of energy efficiency, pricing reforms, and load management programs. A number of energy efficiency and shorter-term demand response activities could be designed and implemented to complement or coordinate with each other, both in the short-run and the long-run. Some promising approaches that would permit program synergies between energy efficiency, demand response, and distributed generation include:

- Increasing the focus on peak load-reductions in energy efficiency programs;
- Coordinated marketing, information, education, and implementation;
- Assessing facility equipment and operations;
- Introducing new technology opportunities; and
- Integrating efficiency with dynamic pricing and metering.

The first two of these approaches contributed to the successful reduction of both energy use and peak load in 2001. Current investor-owned utility programs should continue to combine the synergies of peak load as well as longer-term market orientation. State policy would need to continue to support some form of coordinated informational efforts that actively encourage purchase of energy-efficient products and services as well as keep conservation and efficiency in the public's mind.

Energy efficiency programs can increase opportunities for short-term callable demand response by targeting equipment that enables these actions, (e.g., dual lighting switches, dimmable ballasts, lighting controls and sensors, energy management control systems, and HVAC controls and equipment). Increasing the deployment of communications-controlled appliances and equipment could be an additional focus of energy efficiency programs.

The most promising technology innovations for both energy efficiency and demand response involve cost-based pricing and customer-oriented metering. Pricing strategies based on time-of-use should increase interest in energy efficiency to reduce end-use peak loads that are both coincident with high cost periods and harder to shift, like space cooling and refrigeration. Energy efficiency may be less economically valuable to the consumer for end-use loads that would be easier to shift to cheaper off-peak prices, like laundry, dishwashers, and pool pumps.

Delivering Energy Efficiency and Conservation More Effectively

Two important issues that will impact the effective delivery of efficiency and conservation are determining a form of administrative organization and developing a strategic program planning process.

Administrative Organizational Issues

What is changing the most about publicly supported energy efficiency programs nationwide is their structure and delivery, according to a review and assessment of programs completed by the American Council for an Energy-Efficient Economy in 2000. A variety of organizational approaches are being taken, the form being a function of "a state's individual circumstances, regulatory structure, experience with DSM, and politics."[31] The Council's research sorted administrative styles into three basic categories: 1) utility administration (7 states); 2) independent administration by a government or other non-utility entity (6 states); and 3) a "hybrid" approach, such as California's, which uses utilities as administrators with direction and oversight from state regulators (5 states.)[32]

Changes in the structure and delivery of public benefit programs remain a work in progress. A discussion of how California might end its six-year ad hoc situation and alter its current investor-owned utility administrative structure is currently slated to be part of the CPUC's Energy Efficiency Rulemaking, R.01-08-028. The process of integrated resource planning would be aided by adding greater certainty to the administrative and programmatic structure.

One thing is clear: there is no "one size fits all" for public benefits program administration. California will need to define an administrative structure that fits a statewide, coordinated energy efficiency implementation and spending strategy. CPUC Commissioner Kennedy, presiding commissioner in the Energy Efficiency Rulemaking, indicated in recent remarks[33] that the next two years will likely remain status quo, except for a commitment to multi-year program funding, while an evaluation of recent programs is completed and longer-term transition options can be discussed. Subsequently the Commissioners voted 4-1 in Decision 03-08-067 to continue the funding for current energy efficiency programs in 2004 and 2005.

Three things must happen before any new administrative structure is selected. First, definitions for the roles and responsibilities of administrators need to be agreed upon. Next, necessary qualifications, abilities, and reasonable performance incentives for administrators need to be defined. Finally, a statewide, coordinated program implementation and spending strategy needs to be developed under the joint auspices of the state's energy agencies, but inclusive of all critical stakeholders. The agreed upon public program scope and strategies will define an appropriate administrative structure.

The form of the administrative structure may be less important than a clear and consistent commitment from policy makers to a coordinated, strategic program of energy efficiency and conservation efforts.

Program Planning Issues

The reliance on energy efficiency as an equal substitute for generation would be a substantial shift that would require significant change in the way programs are designed, delivered, and measured. It will be important to combine more of the state's public benefit portfolio components, including research and development, renewable programs, investor-owned and municipal utility programs, state agency programs, and building and appliance standards, into a collaborative, strategic planning process.

The CPUC authorized a series of evaluation studies in 2002 intended to provide a foundation for a more strategic program planning process for public benefit programs. The four studies, scheduled to be completed in 2003, will:

- Summarize the individual electric and natural gas market sector potential studies into a framework useful for portfolio management and integrated resource planning;
- Update the incremental costs and savings data for efficient technologies to be targeted in public benefit programs;
- Develop and implement a method to benchmark and communicate excellent programmatic practices that can enhance the design of energy efficiency programs in California; and
- Develop a new evaluation, measurement, and verification framework that establishes guidelines for the types of studies to be done, the results to be provided, and the appropriate methodologies to be used for various types and sizes of programs.

Aside from the important new policy directions emerging in the Energy Efficiency Rulemaking, several additional CPUC policy directions that will affect the future of energy efficiency program planning and savings achievement are emerging:

- Under direction from the Legislature in AB 1x 29 (2001), the CPUC is breaking the link or "decoupling" the investor-owned utilities' revenues from the volume of electricity sold. With this link in place, even when an investment in energy efficiency is the cheapest resource option for a utility and would reduce customer bills, the utility loses money. California's municipal utilities' revenues continue to be tied to the volume of electricity sales, resulting in a disincentive to invest in energy efficiency.
- The restoration of the investor-owned utilities' portfolio management responsibilities and the integration of energy efficiency into procurement once again reaffirm the utilities' obligation to consider investment in "all cost-effective energy efficiency" in resource planning. As evident in the Procurement/Resource Plan Rulemaking (R.01-10-024), ratepayer funds may once again be available to pursue energy efficiency investments beyond the public goods charge by as much as 60-70 percent over the next five years. This could open the door to program opportunities currently

prevented by PGC funding restrictions, such as integrating renewable or distributed generation into efficiency programs.

- Another far-reaching issue is customer direct access. The abilities of utility customers to choose to receive electric service from private energy providers could have large ramifications for publicly-funded energy efficiency programs. It will be difficult to operate within a resource adequacy framework if utilities are not certain about the size or composition of their customer base.

SETTING STATE GOALS TO FULFILL THE POTENTIAL

This section will consider the need to set state energy efficiency goals and targets in support of the established policy preference for energy efficiency. Criteria to consider in setting savings goals will be addressed. The goals and actions of the joint agency ***Energy Action Plan*** will be discussed.

Goals for Energy Efficiency and Conservation

At least twenty states have adopted Renewable Portfolio Standards, but only three states have adopted a state goal and target for energy efficiency. Each of these states uses a different indicator to express the goal. New York's goal, for example, is a 25 percent reduction below 1990 primary energy use per unit of Gross State Product by 2010. This is reflective of the state policy objective to build a competitive energy services market.

As California transitions back into an integrated resource-planning framework, a state goal will serve to guide statewide policy over the long term and to determine what indicators will measure progress toward that goal. With that goal as a base, a series of mutually supportive targets and indicators developed through a statewide, coordinated planning process can drive implementation strategies, track progress, and trigger corrections as needed. Targets and strategies should focus on immediate energy market problems, but set the stage for the longer range benefits of efficiency such as load growth reduction and environmental quality.

The Energy Commission suggests the following criteria for setting program targets:

- Targets should utilize information developed in the studies of the potential for additional energy efficiency savings, but recognize that programs may need time to ramp up spending.
- Targets should take into account past program experience and current market conditions.
- Targets should be meaningful to the energy efficiency industry and useful for both motivating and tracking program progress in ways that can be understood by a variety of stakeholders.

- Targets should be long-term in nature, but revisited every three to five years to make decisions to either ramp up or ramp down funding based on evaluation efforts and cost-effectiveness results.

Energy Action Plan Goals

California's principle energy agencies[34] joined together in early 2003 to create an ***Energy Action Plan*** to implement their established policy preferences in a coordinated framework. The overall goal of the ***Action Plan*** is to: "ensure that adequate, reliable, and reasonably-priced electrical power, including prudent reserves, are achieved and provided through policies, strategies, and actions that are cost-effective and environmentally sound for California's consumers and taxpayers."

Consistent with long-established state policies, the ***Action Plan*** specifies a "loading order" of energy resources to guide efforts to achieve the goal. Energy efficiency and conservation are placed first in line followed by renewable energy resources and distributed generation as "preferred resources." Additional clean, fossil fuel, central-station generation is placed third, to allow the preferred resources "sufficient investment and adequate time to 'get to scale.'" The bulk transmission grid and distribution facility infrastructure will be improved at the same time to support interconnection of new generation.

The operational goal of the ***Action Plan*** for energy efficiency and conservation is to decrease per capita energy consumption of electricity, in essence to bend the forecasted demand line downward. The ***Action Plan*** designates nine specific actions to decrease per capita electricity use (or "bend down the curve") through optimized efficiency and conservation:

- Implement a voluntary dynamic pricing system to reduce peak demand by as much as 1,500 to 2,000 MW by 2007.
- Improve new and remodeled building efficiency by 5 percent.
- Improve air conditioner efficiency by 10 percent above federally mandated standards.
- Make every new state building a model of energy efficiency.
- Create customer incentives for aggressive energy demand reduction.
- Provide utilities with demand response and energy efficiency investment rewards comparable to the return on investment in new power and transmission projects.
- Increase local government conservation and energy efficiency programs.
- Incorporate, as appropriate…distributed generation or renewable technologies into energy efficiency standards for new building construction.
- Encourage companies that invest in energy conservation and resource efficiency to register with the state's Climate Change Registry.

STRATEGIES FOR REALIZING THE GOALS

While many efficiency activities can fulfill these nine action items, it is necessary to decide which strategies are the most significant for the current situation. This will determine how much of the estimated efficiency potential California should pursue and direct the efforts to formulate policy direction for energy conservation and efficiency program design and implementation.

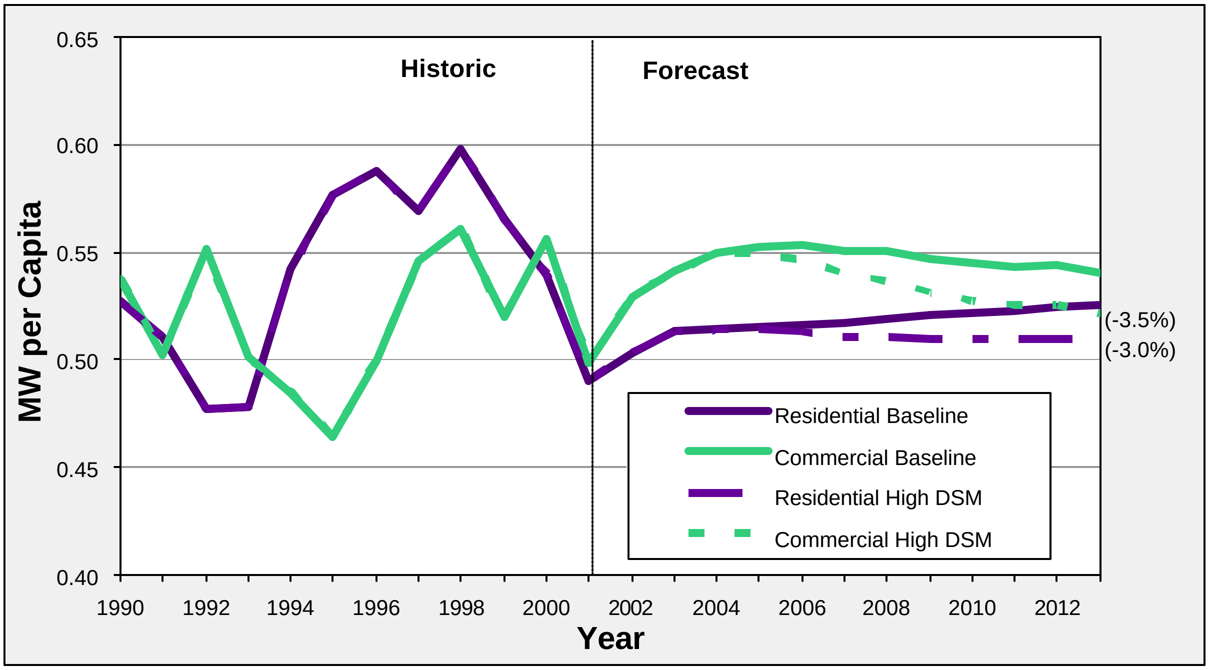
What is the “Right” Amount of Funding for Energy Efficiency?

The larger resource planning issue of how much energy should be purchased through the public goods process and/or procurement is more difficult to answer. The Xenergy potential studies of efficiency potential identify cost-effective funding levels considerably higher than current PGC levels. While it is useful to know that plenty of cost-effective achievable potential remains, cost-effectiveness does not answer the larger planning question of how much energy efficiency should be purchased for the next 5-10 years.

To answer this question fully, an analytical, risk-assessing framework is needed that takes into account increasing levels of demand reduction, increases in supply, induced conservation behavior, volatility in underlying fuel prices like natural gas, and/or the uncertainty of future events. As part of developing such a statewide analytical framework, the Energy Commission prepared scenario analysis of what would happen to the forecasted per capita demand if PGC spending were doubled.

Figure 3-10 illustrates the impact on per capita peak demand of a doubling of the baseline electric efficiency funding for the residential and commercial sectors.

Figure 3-10
Electricity High DSM Scenario: Projected Impacts on Peak Demand per Capita

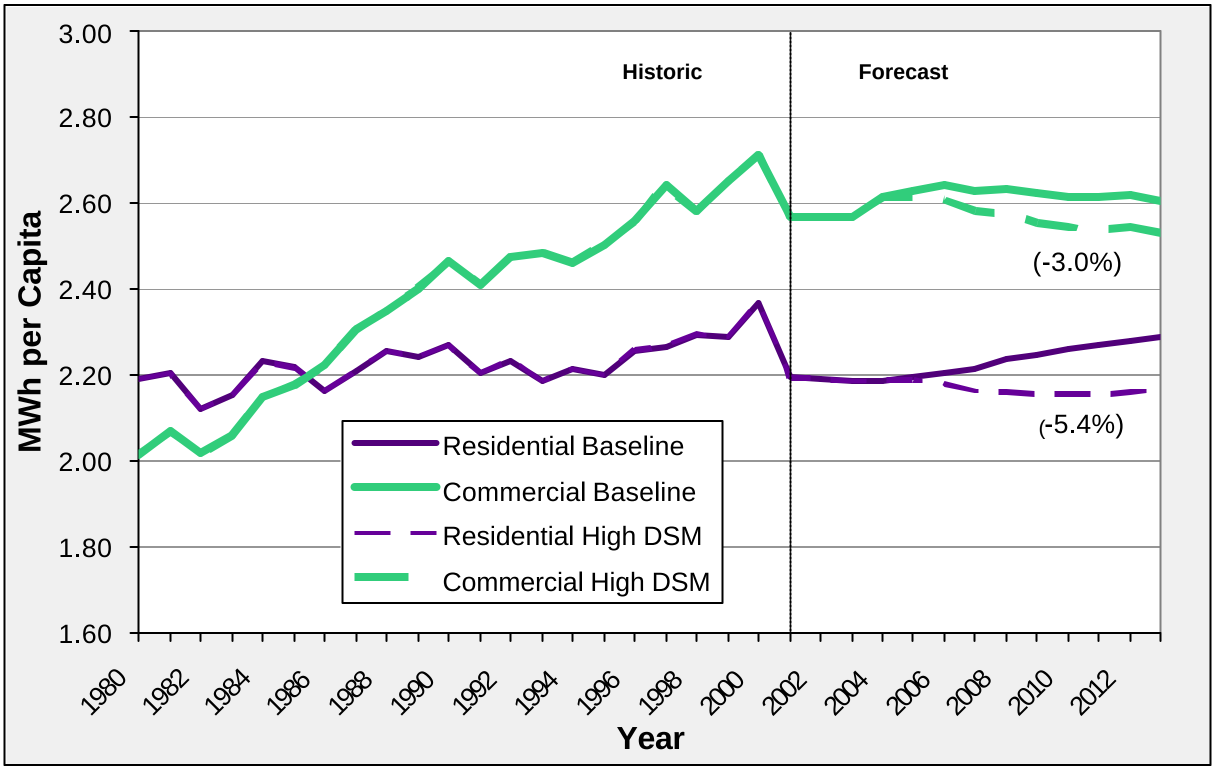


Peak electricity demand per capita could be reduced by 3 percent if PGC funds are doubled
Source: California Energy Demand Forecast, 2003

Most of the peak reduction potential over the next 10 years lies in the commercial sector. Potential future savings in energy consumption are nearly evenly split between the commercial and residential market sectors. The industrial sector is not included here, reflecting the fact that savings in this market are more difficult to capture. As shown earlier in **Figure 3-7**, achieving a larger portion of the remaining potential in the industrial market is more expensive. The customized nature of industrial processes and the difficulty of reaching this audience through conventional efficiency programs are two of the reasons for this difference.

Figure 3-11 shows the forecasted impacts of doubling the baseline efficiency funding on per capita electricity consumption for the residential and commercial sectors, the sectors with the most readily achievable potential. The agricultural and industrial/mining sectors are not shown in the graph. The High DSM scenario "bends down the curve" of overall per capita energy consumption (MWh) by about 4 percent in 2013.

Figure 3-11
Electricity High DSM Scenario: Projected Impacts on Consumption per Capita



Electricity per capita use could be reduced by 4 percent in 2013 if PGC funds are doubled
Source: California Energy Demand Forecast, 2003

To achieve a 0.5 percent per year per capita reduction in energy consumption, assuming population growth is constant at 1.6 percent, the current expenditure level of $235 million per year would need to be tripled by 2008 and funding levels would need to increase to a level of $902 million annually by 2013. It seems unlikely that this level of funding could be supported by the current energy efficiency regulatory infrastructure or that all programs could remain cost-effective. Economic potential in the Energy Foundation study is based on the assumption that a 100 percent increase in customer rebate levels will lead to a 100 percent increase in customer adoption. This assumption is too optimistic. Administrative costs of reaching the final 10-20 percent of customers may be significantly higher than the constant per customer costs assumed in the model.

Lessons from the historical record of energy efficiency program expenditures and savings teach us that:

- Increasing funding levels over a three to five year period is likely to yield more energy savings and be more sustainable than a dramatic increase in the first year of an expansion cycle.

- The optimum rate for increasing program funding over a five year period appears to be in the range of 25-33 percent per year.

The potential for end-use natural gas savings is much smaller than those for electricity, owing to the more difficult nature of tapping this potential and declining per capita consumption at the end-use level.

Two of the ***Action Plan*** efficiency targets will illustrate the magnitude of program effort needed to lower the demand curve. The ***Action Plan*** proposes actions to improve air conditioner efficiency by 10 percent over federally mandated standards and improve new and remodeled building efficiency by 5 percent – a target based upon the Energy Commission's 2005 building standards. California has had great success with its buildings and appliance standards in the past, and should continue to pursue standards as a means of pushing the development and installation of more efficient products and energy efficient buildings.

These measures are important for achieving California's efficiency potential, but alone are not sufficient. Even if California is granted a waiver from the federal air conditioner standards and is able to implement a standard more stringent than the federal standard, the Energy Commission's 2005 building and appliance standards combined are projected to reduce the growth in California's electricity peak by less than 250 MW by year 2013. While not insignificant, this is less than 5 percent of the peak savings achievable with current energy efficiency technologies.

Clearly, the ***Action Plan*** is the beginning of a strategy to achieve the 103 MTh and 1,800 MW of additional peak demand reduction that is possible. System impacts, costs to consumers, and alternative investments will need to be assessed. The following section describes other strategies that can help meet this goal, especially if the value of coupling energy efficiency programs savings with additional resources such as renewable generation and new building and appliance standards.

Policy Strategy Options

The state's principal energy agencies intend to "provide appropriate regulatory guidance, price signals, and incentives to all Californians to use energy efficiently." These responsibilities form the basis for the policy strategy options proposed below. The options are presented in three groupings that encompass the nine actions proposed in the ***Action Plan***. The three groupings are buildings, consumers, and program planning and administration.

Strategies Targeting Buildings

Energy efficiency efforts should be focused in areas where there is the greatest potential for cost-effective savings. This suggests that the buildings sector should be a major focus.

It is the fastest growing sector for both annual and peak electricity demand. Another reason for emphasizing buildings is the potential for CO_2 reduction. Based on California's latest emissions inventory, the buildings sector is responsible for 24 percent of CO_2 emissions, 14 percent by commercial buildings and 10 percent by residential buildings. Because CO_2 accounts for 84 percent of the state's total GHG emissions, the buildings sector represents 20 percent of total GHG emissions.

The strategy options for targeting buildings are divided into two sections: leveraging codes and standards and leveraging market programs and research.

Leveraging Codes and Standards. Support for the capture of additional potential savings could come through regional building standards. Federal appliance standards fall short of their optimal economic achievements in unique geographic regions such as California's Central Valley and the high deserts of Southern California. There is a strong need for region-specific federal standards or for an easing of the federal preemption waiver criteria so that states could adopt region-specific standards. This is especially important for maximizing the savings from climate-sensitive heating and AC equipment.

California has an outstanding record of capturing energy efficiency benefits of equipment in building and appliance standards. The information on how well this equipment is actually operated after installation is inadequate, however. Optimizing the potential savings from equipment means ensuring that it is installed properly and continues to be maintained and correctly operated over a useful life period. Increased program emphasis on quality installation of technologies, including diagnostic testing and field verification in the residential sector and commissioning both new and remodeled buildings in the commercial sector, is needed to leverage the full savings potential of measures included in the standards.

State buildings in California are not required to undergo independent verification of compliance with Title 24 building codes. Instead, the State of California self-certifies that its buildings meet code, relying on individual project managers, architects, and engineers. This is in stark contrast to the process of compliance for private buildings in the state. Creating an independent office dedicated to the review and approval of building plans for compliance with the minimum efficiency levels specified in Part 6 of Title 24 would help institutionalize professional energy code enforcement for state facilities.

Another way to enhance the value of standards is to pay more attention to promoting efficient strategies for using equipment after it is installed. For example, more efficient office equipment is being purchased, but it is unclear that the offices are willing to fully exploit all of their power management capabilities. Using total quality management principles to benchmark state energy management practices against standard industry practices would be one strategy to provide continuous improvement in state facilities management.

In California, the majority of gas-fired appliances must meet minimum energy-efficiency standards set by the federal Department of Energy (DOE). If no federal standard exists, then the Energy Commission may adopt a standard for that appliance. The following gas-fired appliances have state gas-efficiency standards: duct-furnaces and unit heaters, small commercial boilers and furnaces, and site-built boilers. Only three gas appliances have neither federal nor state efficiency standards: gas-fired air conditioners, gas-fired heat pumps, and commercial foodservice equipment.

On May 27, 2003, the DOE published a notice in the Federal Register declaring that it deemed work on setting new gas-efficiency standards for residential furnaces, boilers, and mobile home furnaces to be a "low priority."

Leveraging Market Programs and Research. Given that more than three-quarters of California's existing housing stock was built before the earliest Title 24 buildings standards were in force in 1978, this market is a natural target for aggressive action. A variety of strategies that emphasize both voluntary and regulatory approaches to supplement current incentive programs would be appropriate. Programs could be directed toward new market actors, such as real estate appraisers or title companies.

Incorporating energy efficiency into new office buildings must begin at the very earliest stages of project development. For new state buildings, that would mean as soon as the annual capital outlay plans are released. In reviewing these plans, buildings over a certain size might be identified as candidates for energy reviews. A collaborative effort by a variety of state agencies would strengthen such an effort.

Support for federal or state tax incentives would be another mechanism for leveraging programs and research to improve building energy efficiency. A number of efficiency provisions in the current omnibus energy bills and other federal tax incentive bills for building efficiency proposed in the recent 107th Congress attracted support from a wide coalition of proponents. One such example is providing a deduction of $2.25/square foot for 50 percent savings compared to national standards set by the American Society of Heating, Refrigeration and AC Engineers. Other proposed provisions would have been especially attractive for encouraging high efficiency air-conditioning and reducing peak demand.

Improved natural gas efficiency has been slower to develop than for electricity-using equipment. In fact, the current public goods charge funding does not provide a mandate for natural gas research and development.

Strategies Supporting Customers

Retail electricity rates should reflect the actual cost of generating and delivering electricity on a daily and seasonal basis if we want customers to become more aware and take more actions to reduce electricity use during peak, high-priced time periods.

If we want customers to reliably manage their energy usage, utilities need to provide customers with an accurate web-based picture of their daily usage patterns and an estimated share the appliances and other equipment at their homes and businesses make to peak load. A first step would be to design utility bill information with the customer's needs in mind.

All customers should have the ability to choose a retail rate structure. If the desired result is reduction in peak loads with a move toward off-peak usage, the default rate structure should be some form of time differentiated rate, including some type of fixed or flat rate as an alternate option for a specific length of time.

If we are to move beyond short-term solutions and begin to improve market signals so that emergency measures are no longer required, policies will be needed to help protect against economic shocks and inequities to consumers as we move toward new market structures. Energy efficiency programs will need to:

- Help customers understand how they could benefit from new rate structures and how energy efficiency and price responsiveness strategies could benefit them;
- Identify the most viable demand strategies for different market segments;
- Support testing and promotion of technologies to allow customers to easily respond to high energy prices; and
- Help customers protect themselves from surprise bill risks.

Because occupant behavior is a strong driver of many building end-uses, a better understanding of how occupants interact with buildings and equipment is needed. Inclusion of social science research as part of measurement and evaluation activities would need to be supported. Programs are unlikely to succeed if customer values and decisions are not well- understood.

Strategies Supporting Program Planning and Administration

If the full benefits of energy efficiency are to be realized, administrative certainty for public benefit programs is needed. The scope and strategies of the agreed upon public program should define the administrative structure. A combination of administrative models may be appropriate for achieving different policy objectives.

Support for local government and other non-profit groups to fill market needs that are not being met should be continued. A minimum of 15 percent of PGC funding should be set aside for third party implementers.

Roles and responsibilities for program administrators and oversight agencies should be clearly defined. It is essential that well-designed administrator incentives be tied to achievable short- and long-term goals and that administrators be given flexibility in choosing their strategies to achieve their goals. One possible option would be a base compensation tied to a fixed salary or contract amount with a percentage of the compensation based on actual energy or peak savings achieved.

If energy efficiency is to be used effectively as part of a resource portfolio, more rigorous and independent measurement and evaluation that emphasizes savings estimates and associated uncertainties will be needed to assure its adequacy. The scope, design, and budget of the current DSM measurement and evaluation effort needs to be revised to support a shift to this intensive "resource planning" perspective.

In order to provide robust analyses for resource adequacy planning and procurement activities, forecasts will need to cover shorter time-horizons and more geographically-specific areas, such as transmission planning areas. Data collection efforts and analysis will need to be expanded to support these forecasts and resource analyses.

The goal of reducing per capita energy consumption could be aided by new collaborations across public benefit programs. Legislative support may be needed to allow ratepayer funding to be used on collaborative efforts between public goods program areas such as efficiency and renewable generation.

Expanding energy efficiency programs to include collaboration with distributed generation or renewable technology measures should also be considered. Such efforts have proven successful in other states, such as New York.

Natural gas is an area of increasing importance for California. The emphasis of public benefit programs has shifted to electricity in the last decade. Given this continued direction, the deployment of more efficient gas technologies is likely to be slow in California.

Summer-oriented energy efficiency may be one of the best ways to reduce the demand for natural gas. Reducing winter peak gas demand for consumer and business end-uses may avoid the risk of gas-supply curtailments to electric generators.

CONCLUSIONS

Households, factory managers, farmers, business people, and building operators are among those making millions of energy decisions each day. Few of these decisions are directly about energy. People are interested in cooling their homes, producing goods, or offering services. Energy efficiency and conservation are key components of our future ability to maintain healthy economic growth and a quality of life. Efficiency and conservation have enormous benefits: they reduce electric and natural gas load growth; contribute to flexibility and adequacy of the electric and natural gas systems; offer consumers control over their energy use; offer economic contributions to the Gross State Product; and provide environmental benefits in the form of reduced air emissions and water savings.

Given the apparent cost-effective opportunities remaining, DSM potential should be weighed along with generation, transmission, and storage options in developing the ***Integrated Energy Policy Report's*** integrated infrastructure outlooks. Selecting the appropriate funding level must also take into consideration how quickly programs can be geared up and whether other already-paid-for resources might be displaced. As part of stabilizing the electricity market, utilities have entered into long-term contracts that cover most of the operating hours. In addition, the Renewable Portfolio Standard will be adding new generation. Since customers are already required to pay for these resources, energy efficiency must be assessed as part of a balanced portfolio.

In order to do this, the certainty of energy efficiency and conservation contributions must be improved through vigorous measurement and evaluation, increased understanding of consumer behavior, and robust electricity and natural gas data collection. Energy efficiency and conservation could be made more responsive by more fully integrating them with demand responsive, renewable, and distributed generation programs.

Underlying these issues is the need to deliver energy efficiency and conservation more effectively. This will require administrative certainty and a statewide, coordinated program planning process that includes all critical stakeholders. Therefore, a strategy of "gearing up" appears to be a sound policy direction. This would mean committing to the concept of putting energy efficiency first, resolving program delivery issues, and embarking on a moderate expansion of energy efficiency funding.

CHAPTER 4: DYNAMIC PRICING

INTRODUCTION

This chapter reviews the progress made in developing new tariffs that provide customers with retail prices that reflect market conditions and discusses the remaining issues to be resolved before dynamic tariffs can be made available to a large number of electricity customers.

Following the sudden increases in the wholesale price of electricity during the summer of 2000, and the subsequent rolling blackouts the following winter, the state began to seriously consider the development of technological and regulatory solutions to hedge against future electricity supply problems. One of these solutions is the implementation of dynamic electricity tariffs that price electricity based on the prevailing market conditions and cost of delivering it at any given point in time.

When Californians turn on their air conditioners during unusually hot summer weather and demand for electricity rises sharply, system operators respond by purchasing high-cost generation from seldom-used power plants. While responding to these higher demands by purchasing more expensive energy is no problem for system operators, customers are not informed that the cost of delivering electricity is rising (and that the risks of outages are increasing) until after the fact, usually two to three months later in the form of higher energy bills. Dynamic pricing provides customers with this information about market prices in real time, within hours of the change in market conditions. This allows customers to choose whether they want to pay these higher prices at current usage levels or adjust their consumption to save money. In sum, dynamic pricing would raise prices when overall supplies are scarce and lower prices when supplies are adequate to meet system demands.

California has relied almost entirely upon flat fixed electricity prices for electricity for the last thirty years, and has not conveyed these time-differentiated costs to consumers. As a result we have little experience to understand how customers might respond to time-differentiated pricing. However, it is theoretically true, and has been demonstrated in numerous other locations around the country, that dynamic pricing does work, can be acceptable to participants, and can provide benefits to the entire body of electricity consumers whether they all participate in it or not.[35] Academic experts also make a convincing case that if there are potential abuses of market power in a hybrid or fully competitive market structure, which California clearly knows to be possible, dynamic pricing can be a good way to reduce or eliminate these abuses.[36]

The Energy Commission and the CPUC and the state's IOUs are currently conducting studies to assess the technical and economic feasibility of the implementation of real-time, critical peak and other different dynamic pricing tariffs as strategies for reducing California's peak electric demand. A preliminary conclusion from the ongoing feasibility study is that customers could adapt to dynamic pricing tariffs and reduce their peak demand accordingly, provided that the necessary advanced metering and load control equipment is installed and that dynamic tariffs are available.

If the appropriate tariff structures are implemented, large commercial and industrial customers would be able to reduce their peak electric demand 500 MW by 2005. With development of additional tariffs and programs for all customer classes and refinements in equipment that will allow customers to respond to dynamic prices, about 2,500 MW of peak demand reduction could be achieved by 2007. This is significant, and would greatly assist efforts to make California's electricity system more reliable.

There still exist, however, a number of implementation issues and challenges that need to be addressed and overcome to provide the proper levels of support for dynamic pricing and increased levels of demand response before the estimated magnitude of peak demand savings can be achieved. These challenges range in scope from regulatory issues that stymie the development of any new tariffs, to reducing the cost of installing interval meters. This chapter explores the costs and benefits of introducing dynamic pricing, the outstanding issues, and the challenges that need to be addressed if California is to see the full benefits. This chapter concludes with a list of policy options for consideration by the Legislature.

BACKGROUND AND REVIEW OF RECENT ENERGY AGENCY ACTIONS

Since the 1970s, California's energy agencies have focused on the need to provide customers with more accurate price signals. Pioneering experiments on time-of-use pricing were performed in the late 1970s, and California had active load management programs during most of the 1980s. Unfortunately, agency attention was diverted to and focused entirely on the supply side of the market during the restructuring experiment of the late 1990s. As a consequence, the customer side of the market was totally unprepared for the unanticipated large price spikes that created an electricity crisis in late 2000 and persisted until the late spring of 2001. The energy crisis served as a harsh reminder that a well-functioning electricity market requires flexibility in both supply and demand. Implementation of more demand response-type programs is now commonly included in lists of what California should have done to reduce the electricity crisis of 2000-2001.[37]

Legislative Response to Crisis: Assembly Bill 29X

The dramatic run-up in prices in the summer of 2000 stimulated the enactment of AB 29X (Kehoe, Statues of 2001, Chapter 8) to install interval meters capable of charging customers the rapidly changing costs of providing energy that summer. Assembly Bill 29X provided $35 million for the installation of over 25,000 electric interval, or "real-time" meters, for electricity customers with greater than 200 kW in demand. Whereas existing meters record usage in 6 to 8 hour time bins, the electric interval meters record electricity usage data in 5 or 15 minute intervals. These meters also have the capability to communicate demand and energy usage information, thereby providing customers a new tool for managing their energy costs. AB 29X created the necessary metering and communications infrastructure to enable medium to large commercial and industrial customers to effectively respond to hourly electricity pricing signals in a dynamic or real-time pricing environment.

The CPUC chose not to adopt real time pricing tariffs to reflect these changes in wholesale prices, in part because of widespread uncertainty that these costs were in fact real and not the result of market power manipulations. Despite the inability to provide customers with a real time tariff, the Energy Commission successfully deployed over 25,000 real-time pricing metering systems funded through AB 29X.

The California Legislature has also recently expressed its interest in learning more about the feasibility of implementing dynamic pricing. Senate Bill 1976 (Torlakson, Statutes of 2002, Chapter 850) calls for an assessment of:

> *"…the feasibility of implementing real-time, critical peak, and other dynamic pricing tariffs for electricity in California, as strategies which can either reduce peak demand or shift peak demand…"*

Since this bill was adopted in late 2002, the Energy Commission and the CPUC have worked together to develop and implement time-of-use pricing rates for some customers and critical peak prices for others. Most recently, the CPA has also become a participant in this joint effort. A preliminary conclusion from the ongoing feasibility study is that customers could adapt to dynamic pricing tariffs and reduce their peak demand accordingly, provided that the necessary advanced metering and load control equipment is installed and that dynamic tariffs are available. This report will be delivered to the Legislature November, 2003.

In response to these legislative directions, the Energy Commission has sponsored several workshops that highlighted the opportunities of dynamic pricing and other demand response programs being investigated or implemented by utilities around the nation.

Rulemaking on Dynamic Pricing

In June 2002, the CPUC enacted an *Order Instituting Rulemaking on Policies and Practices for Advanced Metering, Demand Response, and Dynamic Pricing* to investigate a wide range of topics related to dynamic pricing.[38] Shortly after that, the Energy Commission and the CPA were asked to join with the CPUC in guiding that proceeding. In the subsequent year, the Energy Commission, CPUC and CPA have worked cooperatively to develop various forms of demand response for those customers whose load is greater than 200 kW and who already have real time pricing metering systems, and to investigate demand response from residential and small commercial customers who do not yet have the appropriate metering and communication equipment.

Statewide Pricing Pilot for Small Customers

As part of the CPUC rulemaking, an effort to develop a metering and communications infrastructure for small commercial and residential customer classes is currently underway as a statewide pricing pilot program. The pilot is scheduled to be completed December, 2004.

The pilot program is under the auspices of the CPUC and will be implemented by PG&E, SCE, SDG&E, and other regulatory and consumer groups. The purpose is to pilot test the introduction of dynamic rates for a representative sample of residential and small commercial customers. The statewide pricing pilot will install interval meters and offer different dynamic rate forms to over 2,400 customers in all three service territories.

The statewide pricing pilot is designed to measure electric consumption and coincident peak demand impacts for three different tariff options, including:

1. **Conventional time-of-use**. This rate features higher prices during one or two daily time periods (usually from 12 noon to 6 P.M.) when demand is high and lower prices during an off-peak periods (usually from 8 P.M. at night to noon of the following day).
2. **Fixed critical peak pricing (CPP-F)**. This rate includes the time of use rates from the previous tariff and a critical peak price that takes effect during system emergencies for ten to fifteen days per year. The normal two period time-of-use rate is in effect on most days of the year. The critical day time-of-use rate would apply during the ten to fifteen either highest cost or more critical reliability days of the year. customers receive day-ahead notification to alert them that prices will rise to the CPP level on the next day. The higher on-peak price is fixed for the entire duration of the on-peak period. Customers are compensated for the risk of these higher CPP prices by receiving a reduction of 1.5 cents per kWh in their off-peak rate.
3. **Variable critical peak pricing (CPP-V)**. CPP-V rates differ from CPP-F rates in that the critical peak period may be called with only two to four hours notice during the day of a system emergency or dramatic increase in wholesale price event. In addition the higher CPP prices can be limited to a two or three hour period rather than the full 5 to 7 hours during the on-peak time period. Customers on this rate receive a similar discount on the price of energy in the off-peak hours.

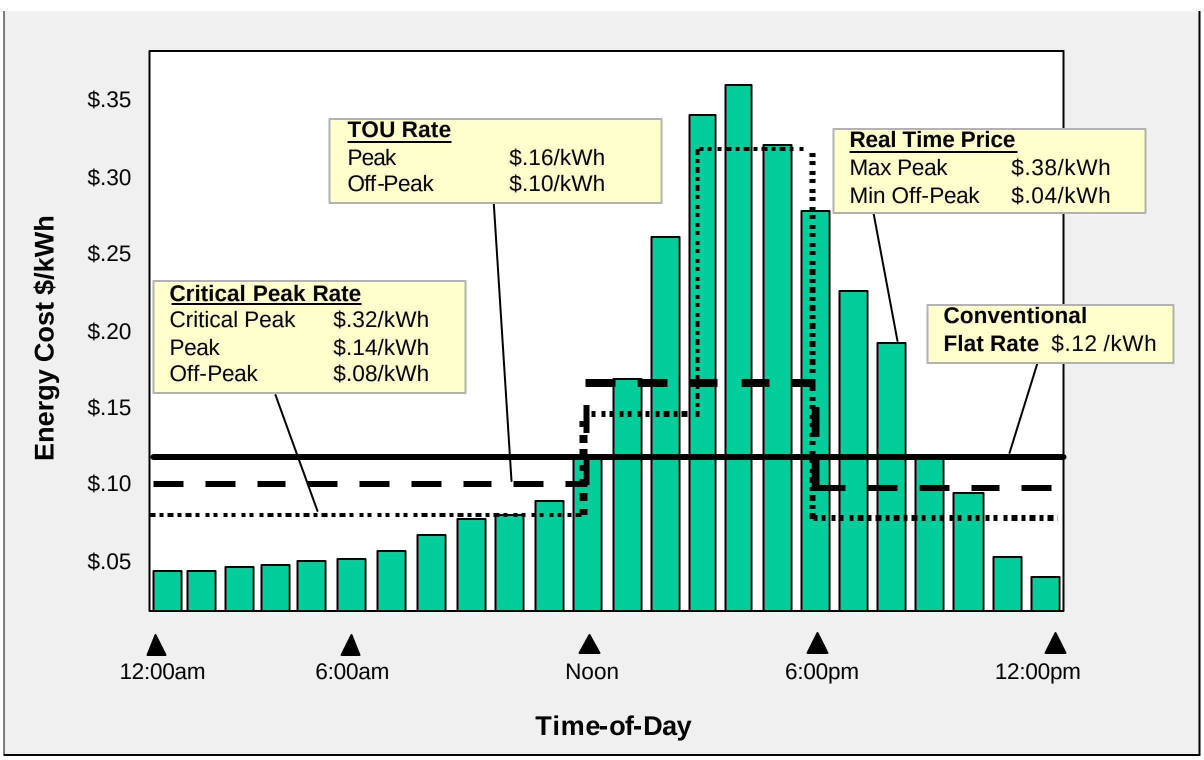
The objective of the statewide pilot is to measure the level of demand response or peak load reductions achieved by these different types of rate structures, to gather data on customers preferences for different forms of time varying prices, and to ultimately use this data to decide if it is cost effective for society to deploy these rates and the supporting meter infrastructure on a voluntary or mandatory basis. The statewide pricing pilot is underway with customers receiving dynamic prices as of July 1, 2003.

Tariff Proposals for Large Customers

The agencies have also been developing dynamic tariffs for larger customers. These rates have been developed for customers with peak loads greater than 200 kW who have the AB 29X real time pricing metering systems in place.[39] These are primarily medium- to large commercial buildings, industrial customers, and some water agencies. In a decision adopted June 5, 2003, the CPUC has implemented two alternative ways in which large customers may voluntarily participate in dynamic pricing; CPP and demand bidding programs. CPP rate uses administratively pre-determined rates on 12 critical peak pricing days each summer season. These CPP days are triggered by temperature conditions likely to be correlated with high spot market prices or use of high cost utility-controlled generators. Load bidding programs allow customers to identify specific price levels at which they are willing to shed a pre-determined amount of load in return for being paid the utility's avoided cost. Neither of these relies upon a market price, but they can be readily modified to use a market price trigger once one becomes available. Real time pricing tariffs are being developed in a second phase of the joint agency proceeding, are proposed to be developed in 2004.

Figure 4-1 provides an example of four different tariffs, two conventional and two dynamic, to illustrate how a dispatchable rate component can impact potential customer costs.

Figure 4-1
Contrasting Rate Impacts - Conventional vs. Dynamic Tariffs



In **Figure 4-1**, the shaded bars represent either a forecast or actual hourly price that might be seen by a customer under a real-time pricing tariff. Under such a tariff, the customer sees and pays the actual hourly cost reflected in the price duration curve. In this example, the straight flat line labeled Conventional Flat Rate reflects the average of the hourly real-time prices. For this particular day, while the customer on the flat rate and real time pricing tariff pay the same total cost, the flat rate customer is being overcharged or undercharged in most hours. The customer on the real time pricing tariff has a financial incentive to control their bill by shifting energy usage into low-priced periods or by reducing usage during high cost periods. The flat rate customer has no such incentive.

The critical peak and time-of-use tariffs provide a more subtle contrast between dynamic tariffs. Both rates provide a peak and off-peak charge, however, the critical peak rate also includes a dispatchable critical peak price. The critical peak price is only dispatched to capture the highest cost hours. Because of the dispatchable critical peak price, peak and off-peak prices for the critical peak tariff are lower than for the same time period covered by the conventional time-of-use tariff. For customers who normally use less power on-peak than the average, a critical peak tariff will result in a lower bill. Customers who use more power on-peak than average will pay more if they do nothing to reduce their usage during critical peak periods. Customers on the critical peak tariff now have a choice to reduce their power bill by either shifting usage to lower priced hours or simply reducing usage during critical price hours.

Agencies have set demand response targets in their interim decision on the development of demand response programs and dynamic rates equivalent to developing the capability to reduce peak load by 1 percent per year over the next five years to reach a 2,500 MW goal by 2007. (***Energy Action Plan*** pg. 14)

The agencies have decided to make participation in this new critical peak pricing tariff voluntary until more information is gathered on demand response and customer acceptance associated with this tariff. Relying upon voluntary participation will help to gain needed experience and allow programs to be fine-tuned for greater participation later. The technologies to allow end-users to respond as quickly and painlessly as possible are just now emerging from research labs and high tech entrepreneurs. Additional refinement is needed before the agencies fully understand the best means to ensure that end-users have automatic devices with the needed sensitivities that will permit customers to respond to dynamic prices in the manner that best suits their needs, rather than manually turning the air conditioner on and off.

ISSUES RAISED DURING RECENT ENERGY AGENCY PROCEEDINGS

Issue 1 - Costs and Benefits of Changing the Default Tariff for All Customers

Benefits of a Default Dynamic Pricing Tariff

Currently residential and small commercial customers are placed on inverted tier rates that do not vary by time of day but increase as a function of total monthly usage. These customers are given no other rate choices. Larger customers are on a time-of-use rate with no other choices. There are three reasons why time based rates may be a better default rate for residential customers:

1. **Time-based or dynamic rates provide a more accurate price signal to customers**, allowing customers to make tradeoffs between investing in more efficient equipment, shifting their load, generating their own electricity, and/or purchasing more electricity from the grid.

   The costs of providing service to California's electricity customers has varied substantially under both conventional and restructured regulatory frameworks. The fact is that the cost of production, whether the resources are owned by the utility or a merchant provider, has always been less expensive to meet base load demand than for peaking resources that are used only a small fraction of the year. Since collective customer usage patterns require a mix of both types of resources, costs vary accordingly. Although hourly cost variation has been a characteristic of the electric utility industry since it began, the ability to measure and bill customers accordingly has not been either practical or economical until recently. As a result, most customers have been placed on flat retail rates where prices do not change as a function of the cost of delivering the service.

   Advocates of dynamic pricing have suggested that the default tariff for all customers should be some form of time-of-use rate to reflect the basic reality that the costs of generating and delivering electricity vary on a seasonal and daily basis. Under this system, all customers would be placed on retail dynamic rates that vary based on these underlying costs but have the option of switching back to the flat or inverted tier rates they have been accustomed to over the last 50 years.

   Customers would pay rates equal to the actual cost of delivering electricity and have incentives to respond to changes in prices at the margin. Over time, customers would begin to reduce their usage during high cost periods by making gradual adjustments in their usage; either by purchasing more efficient appliances used during the high cost period, or changing their usage behavior.

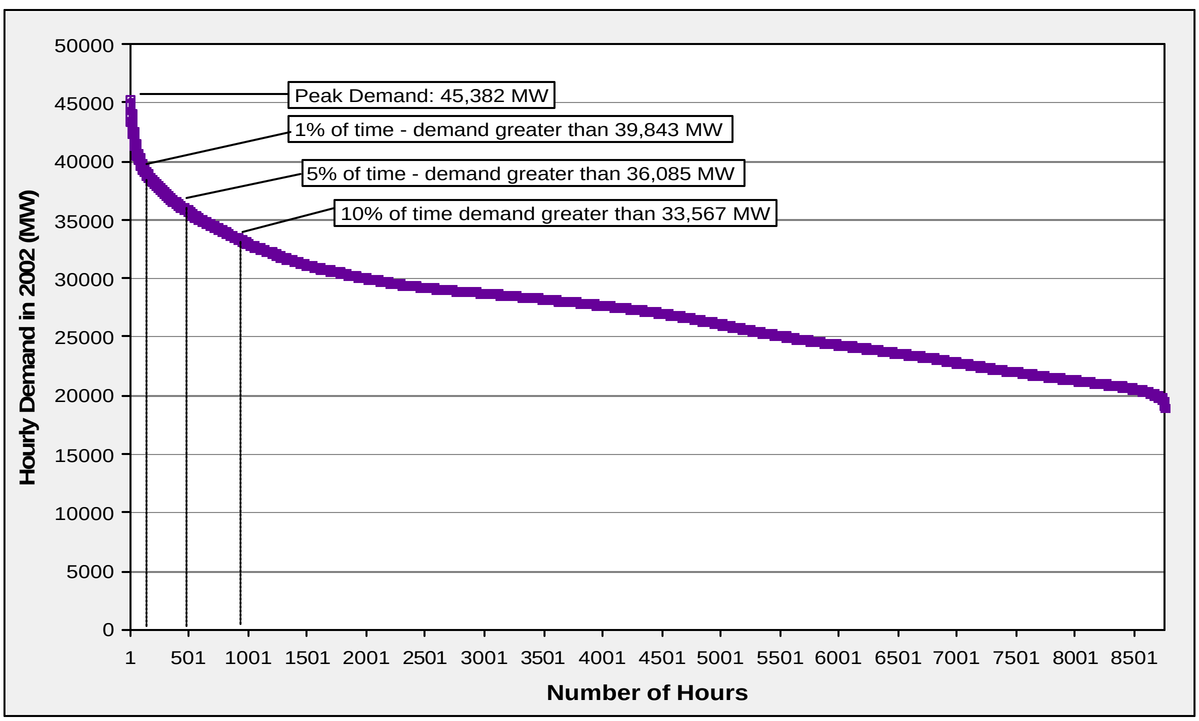
2. **Installing the metering and communications necessary to support a switch to time-based rates will yield other customer service benefits** (such as reduced duration of outages).

A switch to a new default rate based on time-of-use pricing principles would be consistent with the current trend towards upgrading the current metering and billing systems to support two way communication and more frequent feedback to customers on their level of energy usage. The same advanced metering and communication systems necessary to support a change to a new default rate such as critical peak pricing and customer choice can provide electric and gas utilities with substantial automation efficiencies and internal operating benefits that would seem to be a logical part of any business improvement and modernization effort. Furthermore, these systems can provide all customers with information for better managing and understanding their energy usage and investment decisions.

3. **Exposing more customers to the actual costs of delivering electricity will eventually increase system load factors, decrease metering costs, and drive down the costs of delivering electricity**.

Figure 4-2 shows the number of hours that peak demand exceeded 36,000MW in for the IOUs and SMUD in 2002. The figure shows that peak demand for electricity was 45,332 MW but that the overall peak demand exceeded 40,000 MW for roughly 88 hours per year.

Figure 4-2
Load Duration Curve for CA ISO and SMUD in the Year 2002

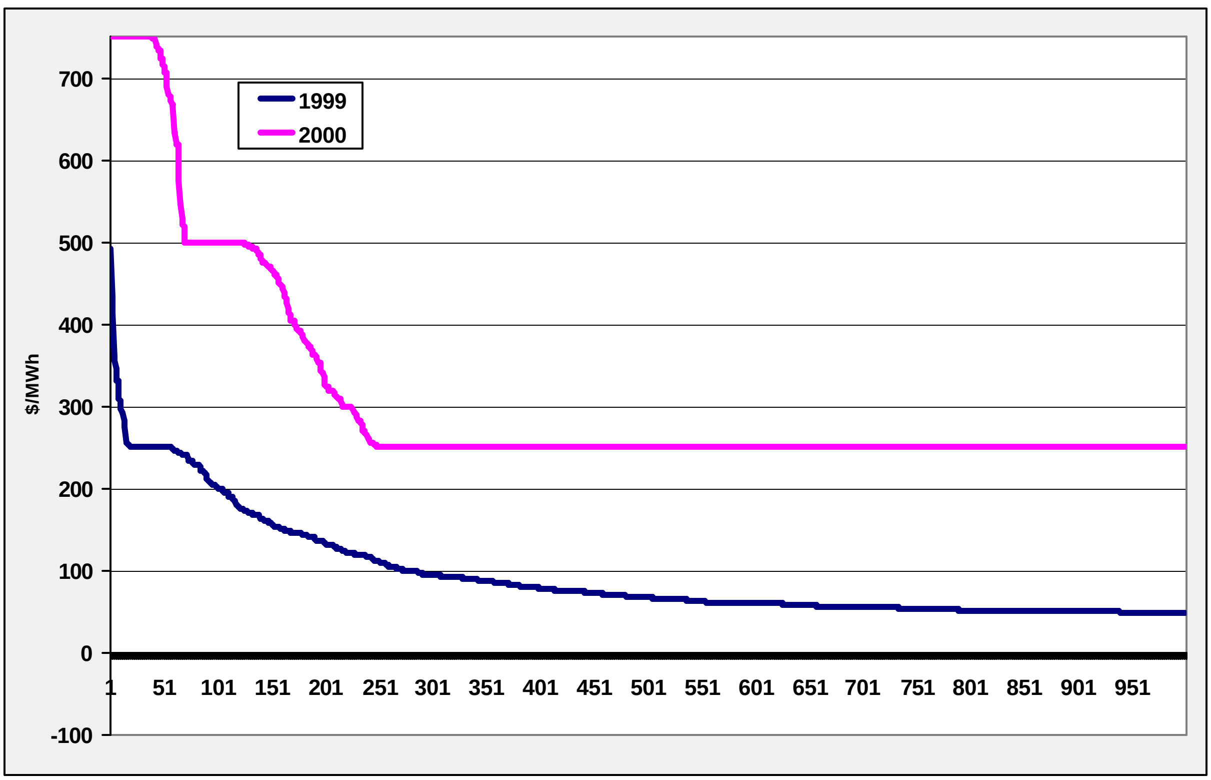


Source: Lynn Marshall, CA ISO/California Energy Commission

The costs of meeting this needle peak can be estimated either by using historical prices paid for peak energy in 1999 and 2000 (see **Figure 4-3**) or by estimating the costs of running a combined cycle power plant to meet the needle peak for 50 to 100 hours per year (see **Figure 4-4**).

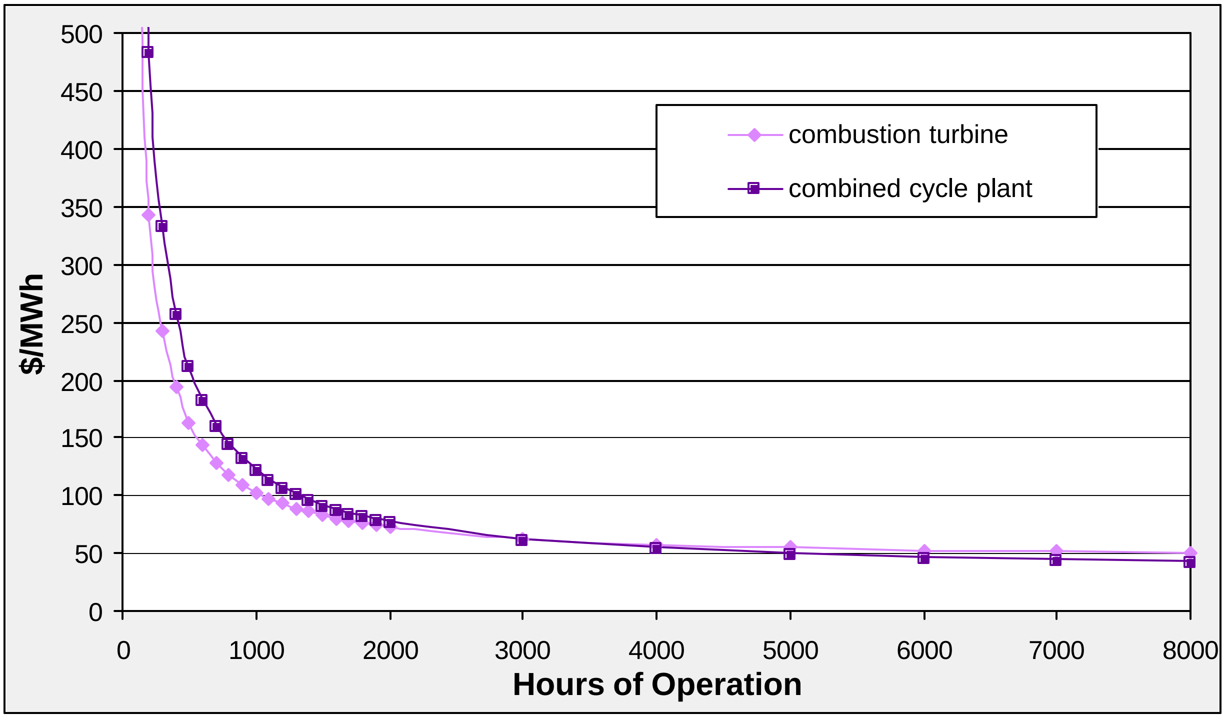
The information from **Figures 4-3** and **4-4** can be used to estimate the costs involved in reducing California's peak demand by 5,000 MW during the 88 hours when peak demand is highest (representing the top one percent of all hours in a year). Based on the historical information from **Figure 4-3**, a reduction in peak demand from 45,000 MW to 40,000 MW would have reduced the price paid for electricity from $750 per MWh to $500 per MWh in the year 2000, and from $420 to $200 per MWh in 1999. This is equivalent to saving $100 million ($250 per MWh x 80 hours/year x 5,000 MW in 2000) for the customers who reduced their peak demand. The savings to the system are much more significant if we assume the $250 per MWh price decrease could have been passed on to all customers. We say "if" because there is some uncertainty about whether the level of market price manipulation occurring during the summer of 2000 and first part of 2001 would have been able to keep the prices high despite the drop in demand.

Figure 4-3
Price Duration Curve Full 8,760 Hours
ISO's Real Time Price in Northern California



Source: Pat McAuliffe, CA ISO data on Market Prices for 2000 and 2001

Figure 4-4
Production Costs as a Function of Operating Hours per Year



Source: Pat McAuliffe, CEC staff.
Note: These costs estimates are consistent with the values reported in the Electricity and Natural Gas Assessment Report, Appendix B: The Cost of Generation.

Using the prospective cost of operating a combustion turbine to meet the peak from **Figure 4-3**, the value of reducing peak demand by 5000 MW can be approximated by the cost of running a peak turbine for 80 hours only per year to meet the same peak increment of 5000 MW. The cost range of providing this energy during the peak is $643/MWH to $832/MWH * 5000 MW* 80 hours/year=$257 million to $333 million.

Thus the value of having the capability to reduce the needle peak via some form of demand response is likely to be significant whether or not the savings are valued using the high peak prices of 2001 or the current costs of providing peak power on the margin from a generic combined cycle plant.

Potential Costs of Switching to a New Default Rate System

Some parties worry that customers with low energy usage will not benefit from a switch to a new default rate. Three reasons are often cited for those who oppose a change in the default rate.

- **Many residential and small commercial customers may prefer flat rates**, even if this means paying a premium above current market costs to ensure stable rates.

Indeed, customers with usage under the 130 percent cutoff line established in AB 1X may have grown accustomed to the fixed and frozen baseline rates.

- **The costs of installing new interval meters and retrofitting utility billing systems** (that were designed based on the premise that customers would not be given a choice of rate forms) may be significant in the short run. The average cost of retrofitting 10 million residential single phase meters over a five year period at $100 per home would be $200 million per year. The actual cost of installing new interval meters is expected to range from $25 to $150 per home and it may be very difficult to install communication links to some rural areas. The primary factor affecting the installed cost per meter is the density of the meters to be retrofit since the drive time of getting crews to the retrofit site(s) is significant.
- **It may be difficult for some customers to adjust their energy usage during peak time periods**. Some customers may perceive that they cannot benefit (reduce their bills) as a result of being placed on critical peak pricing or time-of-use prices as a default. Others may have real difficulties in adjusting their peak usage due to limited budgets or inability to increase the efficiency of their equipment. Customers may resent being forced to switch back from a time varying rate back to their old flat rate.

Assessing the Net Cost to Society of Switching to a New Default Rate

The pilot project will gather data to provide a realistic estimate of these costs of switching to a new default rate, including customer rate preferences, the costs of installing interval meters, and to what extent customers feel powerless to adjust their usage based on these price signals.

The analysis of the costs and benefits of providing customers with a new default rate are inextricably linked to other analytic issues related to the costs of deploying interval meters for all or some customers. For example, should the costs of installing new metering and communication systems (described in the bullets above) just be considered a cost of providing better service to customers or should they be attributed only to the costs of establishing new tariffs? Or, should these metering installation costs be split or shared between the benefits that will accrue to normal utility operations and the benefits of achieving greater demand response?

The analytical challenge of how to compare the costs of changing the current default inverted tier rates to a time-of-use or critical peak price rate will be considered in the second phase of the CPUC's proceeding on dynamic pricing. The preponderance of evidence considered to date suggests that a switch to a new default rate is likely to be cost effective for many customers with the ability to shift loads but the actual cost effectiveness of installing meters for smaller customers will depend on the level of system wide benefits generated by universal deployment of new meters and dynamic rates. These system-wide benefit estimates depend on assumptions about future market price volatility and the unit costs of deploying the interval meters and upgrading communication systems. These are still not known with sufficient certainty to predict the outcome of this policy choice. The results of this analysis should be available by the spring of 2004.

Issue 2 - Universal or Widespread Deployment of Interval Meters and Dynamic Rates

The largest unresolved question before the joint energy agencies is whether the pursuit of a universal deployment strategy for advanced metering and automatic control equipment will significantly reduce the per unit meter installation costs to the point where it is more cost effective to hook all customers up even if only a fraction of the customer base chooses to use dynamic pricing. If these scale economies in deploying advanced meters are significant, even small usage customers would receive sufficient net system wide benefits related to the reduced costs of meeting system peak demands to justify the costs of installing a meter at their premise even if they elect not to participate in dynamic tariffs. Understanding whether small customers will benefit from this type of rate and if in fact some will choose to participate in dynamic pricing tariffs is part of the statewide pricing pilot. This effort began in summer 2003 and continues through 2004 in order to develop an understanding of how small customers respond to various price patterns, with and without automatic control equipment.

This understanding of small customer response and the economics of mass meter deployment will be a key input into the question of universal deployment of advanced metering systems. At this point it is unclear whether California will follow the lead of many utilities around the country and install these systems for all customers,[40] or settle for a smaller scale deployment of interval meters focused just on particular classes of customers who are likely to provide significant levels of demand response.

Issue 3 - Customer Acceptance of Dynamic Pricing in the Mass Market

Even after ten years of experimentation with time-of-use rates in other states and to a limited extent in California, it remains unclear what fraction of the market would voluntarily opt for a time-based rate. Most customers intuitively report that the costs of electricity must be higher on hot summer afternoons, but this does not mean that they are willing to switch to a more cost based rate or pay higher prices in the afternoon.

Recent market research suggests that many customers are willing to adjust their energy use in response to price signals. Research conducted by Lutzenheizer showed that:[41]

- Residential customers in California have shown a willingness to conserve, particularly under exceptional circumstances.

- Consumers recognize that energy systems problems have become a fact of life, therefore, they can, in effect, be "demand responsive."
- Consumer concerns about affordable energy services would suggest that dynamic pricing policies would have to provide demonstrable bill savings to consumers.
- Time-of-use rate experiments show customers are willing to accept time-of-use rates and associated shifts in demand if they are placed on the rate, but those same customers are unlikely to volunteer for such new rates primarily because of inertia and the fact that the savings from joining the rate are either not well known or worth the costs of making the change.

Evidence gathered to date in the pilots suggest that only 25 to 30 percent of customers would voluntarily choose to switch to a time-of-use or CPP rate because of uncertainties about how much their actual bill would go up or down and to what extent they could reduce their peak usage during high price periods. However, as many analysts have already pointed out, dynamic pricing may be successful if only 20 percent of the customers in any given class switch to a dynamic rate because they will provide a sufficient level of demand response and create substantial benefits for all customers.

Issue 4 - Availability of Real time Market Prices

To implement dynamic pricing tariffs and programs requires that market participants have access to transparent wholesale market prices upon which to base a customer tariff. Since the demise of the California Power Exchange, the emergency procurement of power contracts by the Department of Water Resources in 2001-2002 and now the utilities' decision to keep many of its contract terms confidential, California has lost the most valid, transparent source of market prices. Because of this, the original thrust of collective agency efforts toward implementation of real-time pricing tariffs has been temporarily redirected into other forms of dynamic pricing until the CA ISO recreates an acceptable, transparent market price signal.

Issue 5 - Dependable Level of Peak Load Reductions Available from Emergency Price Signals

System operators are still unsure of the level of peak load reduction or demand response that can be expected if retail prices rise by 50 to 200 percent during a heat storm or other system emergency. They are skeptical that price increases alone should be relied on to curb peak usage when there are other direct control alternative such as automatic load cycling devices that have proven results even though their costs are often hidden until the time the crisis hits. There has been a concerted effort to measure the level of price response that can be expected from different types of customers as discussed below. But, in reality, it will take at least a few months of experience with the dispatch of critical peak prices before system operators will rely on this mechanism.

Over the last 25 years there have been numerous studies by California investor owned and other utilities to examine peak load and energy impacts from a wide variety of rate and pricing structures. Some efforts focus only on the measured peak reduction while others have measured the peak reduction in response to a specific price increase, e.g. the price elasticity. Price elasticity is defined as the observed percentage change in demand in response to the percentage change in electricity for a given time interval. Thus, if the price of electricity jumps by 50 percent and customers respond by reducing demand by 20 percent, the price elasticity is -0.2/0.5= -0.4. This type of price signal could provide a significant drop in an emergency situation, For example if 20 percent of the current load included customers who were on dynamic rates, a 50 percent price spike could drop total load from 50,000 MW to 46,000 MW, a 4000 MW drop which is more than twice the peak load reduction achieved by interruptible programs during the summer heat storm of 2000.

The research literature on price elasticities was extensively reviewed and documented in a formal report as part of the joint energy agency process to develop new rate forms. The results are illustrated in **Table 4-1** below.

Table 4-1
Survey of Customer Demand Response Estimates[42]

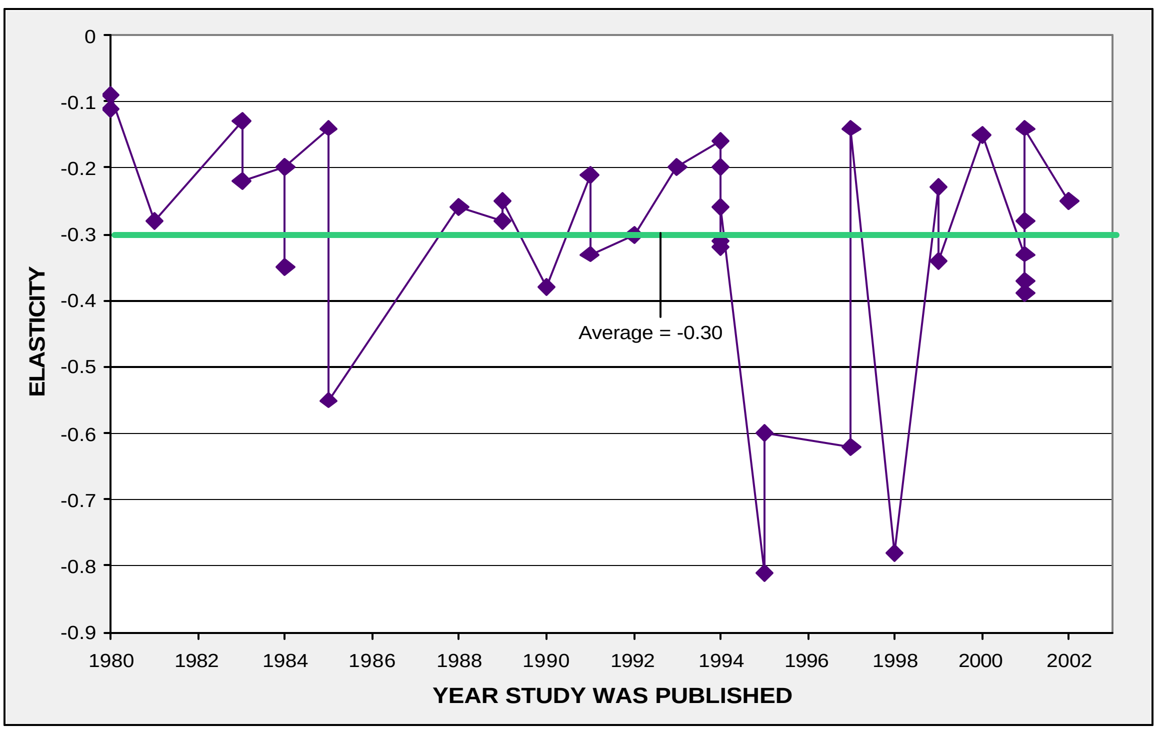
Program Type	Range of elasticities	Range of peak demand reduction	Range of total usage reduction
Residential time-of-use	-0.05 to -1.3 *(SCE; North Carolina)*	4 percent to 35 percent *(Ontario; Duke)*	0 percent to 23 percent *(PG&E; Connecticut)*
Residential critical peak pricing	-0.35 to -0.82 *(GPU; EdF France)*	42 percent to 59 percent *(Gulf Power; AEP)*	0 percent to 6.5 percent *(AEP; Gulf Power)*
Small commercial time-of-use	-0.03 to -0.04 *(SCE; PG&E)*	None reported	2.1 percent to 5 percent *(McKinsey multi-utility data; Finland)*
Small commercial dynamic pricing	No studies	No studies	No studies

Figure 4-3 provides an illustration of how the results from price elasticity studies in the electricity market have been fairly stable over time. The results suggest that the demand elasticity is fairly inelastic in the short run with elasticities that range from -0.1 to -0.4 across a range of customer types and publication dates for the studies.

The statewide dynamic pricing pilot is designed to fill the gaps identified in **Table 4-1** and to reduce the uncertainties inherent in existing response results reported in the other accompanying tables and figure. The price elasticity results of the existing literature, when combined with results from the pilot, will provide the CPUC with a database that can be used to accurately predict demand responses for new California programs.

However, all reported results including those from the statewide pricing pilot are derived from experiments that have some substantial limitations. Experiments typically measure only short-run elasticities, those changes in usage that customers can accommodate by modifying their existing lifestyle patterns and equipment usage. These experiments do not measure long-term elasticities that might reflect customer decisions to purchase more energy efficient equipment or more permanent structural changes to reduce overall energy usage. In addition, all experiments are subject to experimental design, customer education, random uncontrollable weather and other environmental conditions, and pilot implementation problems, which can substantially affect both the validity and degree of customer response.

Figure 4-5
Price Elasticities in 36 Studies Published Between 1980 and 2003 Show an Average Reduction in Usage of 30 percent for Every 100 percent Increase in Price[43]



PILOT TESTS

The overall objective of the statewide pricing pilot is to produce information to guide the decision on full-scale deployment of dynamic tariffs. Thus the pilot tests and the evaluation of the introduction of the new critical peak pricing rates for large commercial and industrial customers have been structured to resolve the remaining issues related to customer acceptance, expected price elasticities, and the cost effectiveness of deploying interval meters to all customers. The only significant remaining issue that the pilot tests and large customer evaluations are not addressing is the issue of how to make market prices transparent to the general public and thus form the basis for the future development of hourly pricing options.

The voluntary tariffs and programs recently implemented by the state's energy agencies and investor-owned utilities will not be useful unless they attract substantial numbers of customers willing and able to participate on a sustained basis. The goal is to recruit a stable and significant set of customers that can provide an active demand response capability that can discipline market power and provide benefits to both participants and electricity consumers at large. California electricity consumers are jaundiced. They have been burned by poor market performance and asked to pay for enormous amounts of sunk costs from utilities and the Department of Water Resources. In most customer classes, bundled service rates for core customers are now the highest in the country. In most hours of the year market prices (as measured by bilateral contract trading indices and CA ISO real-time prices) are far below average rates. It is expected that participation in these critical peak pricing tariffs and load bidding programs will be low at first. Incentives will be offered on a transitional basis so that enough customers choose to "pilot" these efforts that the participation issues can be thoroughly understood.

The agencies plan that participation in these initial programs will grow over time and contribute toward a goal of five percent of peak load, or about 2,500 MW, by 2007. Additional tariffs and programs for larger customers and some form of tariffs and programs for smaller customers will also be needed to achieve these goals. This capability will displace the need to build large numbers of combustion turbines held in standby for peaking purposes, using up scarce generating facility locations and limited offsets needed by all facilities requiring New Source Review air quality permits.

As a result of the market dysfunction in 2000 - 2001, some do not believe that price should be used as a tool to motivate demand response. They wish that prices could be firmly controlled and not exhibit any volatility. Unfortunately, the reality of electricity generation is that costs can vary quite strongly across the hours of the year. In fact, prices always rise when reliability is threatened and it makes sense to communicate those prices and a sense of urgency to customers since higher prices at the margin are almost always preferable to system black outs. Eliminating market power abuses by merchant generators does not mean that it costs the same to provide electricity at all times of the year or that reliability problems or emergencies will disappear. The retail pricing system should reflect this reality.

RECOMMENDATIONS

Accordingly we recommend a three step process to achieve the goal of providing all customers with a choice of flat, inverted tier, time-of-use or critical peak pricing rates by the end of 2008.

1. **Complete Work on the Existing Pilot Test for Small Customers and the Evaluation of Critical Peak Pricing Tariffs for Large Customers.** The joint agencies should continue to work together with the Investor owned utilities to complete the statewide pilot test and evaluation of new CPP rates for large customers, analyze the data, and disseminate the results to key stakeholders, including the Legislature. These results will be critical in helping to resolve the issues raised earlier in the chapter and developing the best strategy to deploy these rates to some or all rate payers.
2. **Continue Joint Agency Collaboration and Conduct Customer Education Activities.** The joint agency collaboration exhibited in the current proceedings (R.02-06-001) should continue to advance dynamic pricing for those classes of customers who already have advanced metering systems. Voluntary or mandatory tariffs, augmented by programs, can achieve considerable system and customer level benefits. Phase 2 of the rulemaking should continue to pursue development of the business case for advanced metering and shoring up the states emergency demand response program and tariffs. A substantial educational effort targeted at the mass market should be designed and undertaken beginning in 2004.
3. **Deploy Advanced Metering Systems if Business Case Analyses are Favorable.** The agencies should complete their review of the costs and benefits of different strategies to deploy interval metering and dynamic pricing by the winter of 2004. These results should be presented to the Legislature along with an offer to help craft legislation that should guide the deployment of metering systems found to be cost beneficial for the customers of investor owned and municipal utilities. At this point, the state will need to decide whether to deploy interval meters to all customers or just selected customer classes over a three to five year period.

During the implementation stage, care should be taken to ensure that all customers have access to new information about their own electricity usage patterns and the prices they pay. This information has already proven to be very valuable for businesses that have installed interval meters over the last three years Distribution companies should also provide customers with tips on how they can adapt their usage patterns.

The agencies should brief the Legislature on the need to selectively eliminate or modify specific statutes enacted during the crisis that currently forbid rate structures to be changed for sensitive customer classes . Alternative methods of protecting customers through the use of lump sum payments or discounts off of new dynamic pricing rates are likely to be more effective than freezing the development of new rates for an indefinite time period.

In sum, much progress has been made in developing new forms of dynamic tariffs but it is likely to take concerted action by California's energy agencies and Legislature over the next three to five years to make dynamic tariffs available to all customers and verify the expected positive results. We believe that the significant potential to increase the level of customer service, stabilize energy prices, and increase the reliability of the electricity system through the deployment of dynamic rates over the decade will significantly exceed the costs of deploying the new rates and interval meter systems.

CHAPTER 5: RENEWABLE ENERGY

INTRODUCTION

Together with DSM and research and development, renewable energy is a key component of California's public interest energy strategies. In 2001, 11 percent of retail electricity generation in California (excluding self-generation) came from renewable energy resources, defined in California as electricity from geothermal, organic waste, wind, solar and the portion of hydroelectricity generated by systems that are 30 MW or smaller. As a result of California's RPS and efforts by municipal utilities, the proportion of California's electricity generated by renewable resources is mandated to reach 20 percent of electricity retail sales by 2017, within certain cost constraints (Senate Bill 1078 [SB 1078], Sher, Chapter 516, Statutes of 2002.) The state's energy agencies recently proposed accelerating the RPS, to achieve 20 percent by 2010.[44]

This chapter summarizes trends and outlooks and driving policy issues for renewable electricity in California, with reference to the broader Western Electricity Coordinating Council (WECC). The WECC includes the following states and provinces: Alberta and British Columbia, Canada; a section of northern Baja California, Mexico; Washington, Oregon, California, Idaho, Utah, Nevada, Arizona, New Mexico, Colorado, Wyoming, Montana.[45]

Setting California's RPS in the context of historical policy direction, existing renewable generation, and technical potential in California and the WECC, the chapter reports on costs for a number of different renewable energy products, provides an estimate of recent proposals given market prices and other barriers, discusses expected trends given RPS requirements, and presents a plausible scenario for achieving the statewide RPS targets. The chapter then discusses the benefits and challenges of expanding renewable electricity in the electricity system, including energy diversity and security, climate change, NO_x emissions, and environmental issues associated with various renewable energy resource types. The key issues associated with laying the groundwork for expanding the use of renewable DG in California are briefly introduced, followed by the driving policy issues associated with achieving California's RPS. These include transmission constraints, sufficiency of public goods funding, operational compatibility, financing for new renewable generation, and issues related to statewide RPS. Key themes from this chapter are summarized in its concluding section.

TRENDS AND OUTLOOKS

The outlook for renewable energy in California promises aggressive investment in renewable energy development. This investment may extend to renewable resources located in other states of the WECC, within the boundaries of policies affecting interstate development of renewables and transmission system constraints. This section highlights trends in the following areas: renewable energy policy, existing renewable generation, technical potential, and costs. It also provides information about recent development proposals, the estimated amount of renewable electricity required to meet California's RPS requirements, and a plausible scenario for meeting California's RPS requirements in 2005, 2008, and 2017.[46]

Brief History of Renewable Energy Policy in California and Other Western States

Support for renewable electricity resources in the states of the WECC is increasing, although it varies widely from state to state. In California and other states of the WECC, support for renewable electricity has been dominated by three policies: the federal Public Utility Regulatory Policies Act (PURPA), market-based incentives supported by PGCs, and, most recently, RPS policies.

The federal PURPA spurred the development of the renewable industry in California and other states of the WECC. PURPA required that utilities purchase electric power from independent generators, many of which used a renewable resource such as biomass, wind, and solar energy to generate their electricity. In California, many of these renewable facilities signed Interim Standard Offer 4 (ISO4) contracts that provided escalating fixed energy payments for 10 years. However, these contracts shifted from a fixed price to natural-gas based variable prices in the 11th year, creating a price "cliff." Because the variable prices were as much as 85 percent lower than the fixed prices received at the end of the tenth year, 300 MW of electricity generation from renewable energy were shut down between 1993 and 1997.

In 1996, California restructured its electricity market. When the state moved to a de-regulated market structure for electricity, there was concern that the "stranded benefits" inherent in the state's developed renewable industry would be lost in the transition to competition without governmental assistance. Generating electricity from renewable sources has been generally more expensive than the cost of generation from fossil fuels, but it comes with public benefits that are difficult for the market to take into account. To address this concern, California adopted a $540 million Public Goods Charge (PGC) program (1998-2001) to support the development of renewable resources (Assembly Bill 1890 [AB 1890], Brulte, Chapter 854, Statutes of 1996,). This program was extended and expanded by Senate Bill 1194 (SB 1194, Sher, Chapter 1050, Statutes of 2000) and Senate Bill 1038 (SB 1038, Sher, Chapter 515, Statutes of 2002.) SB 1194 authorizes collection of PGC funds of at least $135 million per year during 2002-2011. The funds are spent through a market-based program that stimulates supply and demand for the purchase of electricity from existing, new, and emerging renewable electricity resources.

Implementation of the support for new renewable electricity generation plants in California was hampered by the recent energy crisis. In 2000-2001, California suffered tremendous turmoil in the natural gas and electricity markets. As a result of the crisis, the California Power Exchange went bankrupt, utilities were either unable or unwilling to buy from new sources of electricity, and the option of selling renewable electricity directly to consumers (i.e., direct access) was suspended. These developments left most proposed new renewable facilities without buyers for their electricity.

To address the problems raised by the 2000-2001 energy crisis and further promote the development of renewable resources, the California Legislature passed Senate Bill 1078, creating California's Renewables Portfolio Standard (SB 1078, Sher, Chapter 516, Statutes of 2002.) The RPS program requires IOUs, Electric Service Providers/Community Choice Aggregators (ESP/CCA), and other regulated entities to provide 20 percent of retail sales from renewable electricity resources by 2017. Municipal utilities are also encouraged to increase their use of renewable electricity resources. The state is working to accelerate achievement of the RPS goal from 2017 to 2010.[47]

Support for renewable electricity is also increasing in other states of the WECC. Montana and Oregon collect funds for renewable electricity development through public goods funds. Nevada, Arizona, and New Mexico have passed renewable portfolio standards with the following goals:[48]

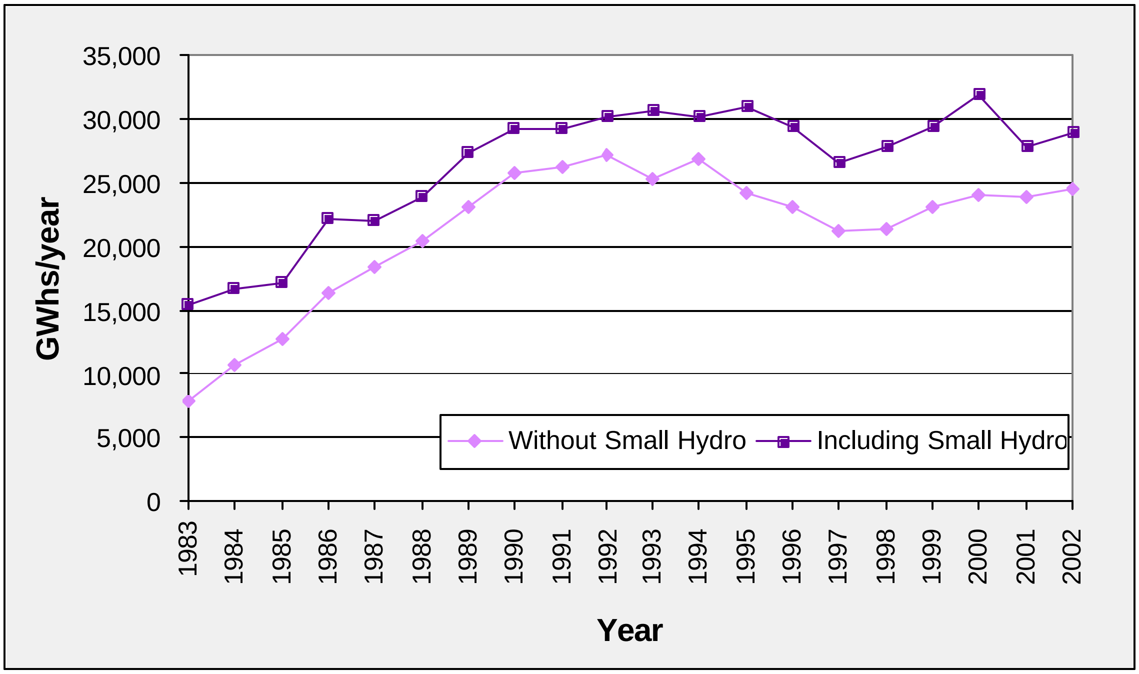
- Nevada plans to have 15 percent of its electricity come from renewable resources by 2013. At least 5 percent of the renewable energy procured under Nevada's RPS must come from solar energy systems.[49]
- Arizona plans to have 1.1 percent of its energy come from renewable resources by 2007 until 2012, with at least 60 percent of the 1.1 percent coming from solar energy systems.[50]
- New Mexico plans to have 10 percent of its energy come from renewable resources by 2011.[51]

Existing Renewable Generation

Although renewable electricity generation in California was impacted by a drop in revenue in the mid-1990s (see **Figure 5-1**), renewable energy production, including small hydroelectric power (30 MW or smaller), grew from 8 percent (15,521 GWh) of electricity generation in 1983 to 15 percent by 1992. Renewable energy production dropped from 1992 to 1997, due to the shift in many ISO4 contracts from fixed to variable prices and restructuring of the electricity market. In 1998, SB 90 launched the Renewable Energy Program and renewable energy production began to increase again. In 2001, renewable electricity generation provided 11 percent (27,759 GWh of 265,059 GWh less 10,000 GWh of self-generation) of California electrical generation (including imports).[52]

Geothermal energy provides the largest portion of renewable electricity in California, where renewable electricity is defined as electricity from geothermal, organic waste, wind, solar and hydroelectricity generated by systems that are 30 MW or smaller.

Figure 5-1
Trend in Renewable Energy Production in California (1983-2002)



The installed capacity of photovoltaic (PV) systems is growing rapidly in California. The PV systems installed in 2002 increased the cumulative installed PV capacity in California by more than 80 percent.[53] Staff estimates that about 43 GWh (about 33 MW) of electricity were produced in 2002 from PV systems in California.

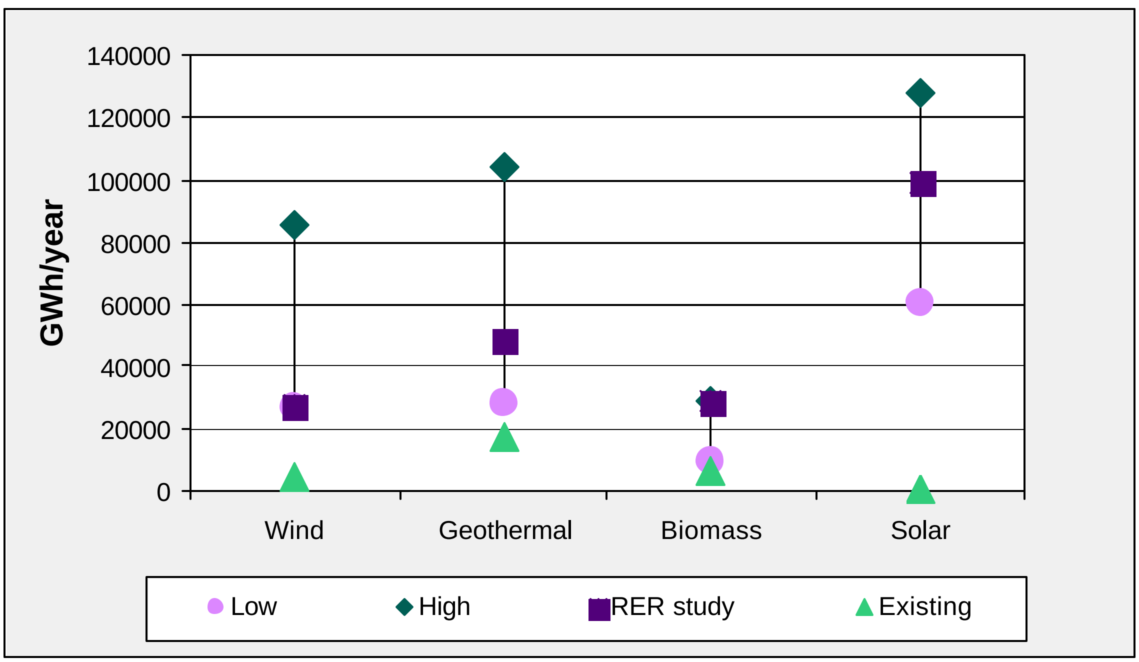
More than 8,500 GWh/year of electricity in the WECC states beyond California is produced from wind, geothermal, and biomass. Renewable energy (excluding small and large hydropower) provided four percent of the region's energy production (including California).[54] As discussed above, policies are in place to increase the use of renewable energy in the WECC.

Technical Potential

Using a 2002 study by Regional Economic Research, Inc., ***Technical Potential of Renewable Resource Technologies***, as a base comparison, **Figure 5-2** displays the range of renewable energy technical potential for wind, geothermal, biomass, and solar (including PV) in California. This figure includes existing and proposed renewable energy facilities. Range bars show the difference among technical potential estimates across studies.[55] For example, the lowest estimate of technical potential for California geothermal in the studies reviewed for this assessment was 28,200 GWh/year. The highest estimate for geothermal in California was 104,300 GWh/year. By way of comparison, total electricity generated in California in 2002 was 272,509 GWh.[56] Overall, existing renewable energy facilities utilize a small proportion of the technical potential for renewable energy in California.

Regional Economic Research, Inc. estimates the technical potential of roof-top PV energy in California to be about 9,450 MW (18,000 GWh/year).[57] The potential for roof-top solar electric systems on California municipal buildings is considerable. Using roof area estimates of 66 million square feet, the National Renewable Energy Laboratory (NREL) estimated the capacity potential of 198 MW on municipal buildings and 1500 MW on schools.[58] Energy produced from PV at these locations could be about 2,200 GWh/year.

Figure 5-2
Technical Potential in California, by Technology (GWh/year)



Data on technical potential for biomass, geothermal, wind, and solar for the other WECC states come from the ***Renewable Energy Atlas of the West***. These studies indicate that the total technical potential (including existing and proposed projects) for renewable energy in Washington and adjacent WECC states totals more than 190,000 GWh/year. The technical potential for wind in the outer tier WECC states is so large (more than 2,000,000 GWh/year) that it dwarfs the potential for geothermal and biomass by comparison. The geothermal and biomass technical potential in the outer tier WECC states totals more than 30,000 GWh/year.

Cost Trends by Technology

Table 5-1 indicates the cost of electricity production from a variety of different renewable energy resources.[59] These resources differ from one another in terms of the type and timing of electricity that they produce. The table shows a trend of declining costs of renewable generation over the past two decades.

Table 5-1
Cost Trends in Electricity from Renewable Energy by Technology

Technology	Cost (cents/kWh) in 1980	Current Cost (cents/kWh)	Estimated Cost (cents/kWh) in 2017
Wind	35 [a]	4.9	3 [e]
Geothermal (flash)	10	4.5	4.5 [e]
Biomass	12 [a]	6.5 [b]	5.7 [e]
Biogas (landfill)		3.2 - 4.0 [d]	3.7 [e]
Solar thermal electric (parabolic trough with 25 percent natural gas)	60 [a]	13.5	6 [e]
Solar photovoltaic	95 [a]	25 [c]	15.6 [e]
Ocean wave energy	unknown	7.5 [b]	unknown

Source (unless otherwise noted): Comparative Cost of California Central Station Electricity Generation Technologies, Prepared in support of the Electricity and Natural Gas Assessment Report under the Integrated Energy Policy Report Proceeding Docket 02-IEP-01, June 5, 2003. Other sources: a) NREL Energy Analysis Office (www.nrel.gov/analysis/docs/cost_curves_202.ppt). b) EPRI, Renewable Energy Technical Assessment, Guide-TAG-RE 2002. C) "Grid-tied markets for photovoltaics - a new source emerges" Renewable Energy World, Vol. 4, No. 4, July/August 2001, page 177. d) Messics, Mark, Waste Management, Inc. (2001), "Landfill Gas to Energy," 2001 Conference Proceedings, U.S. DOE Natural Gas/Renewable Energy Hybrids Workshops, NETL Publications. Available online at http://www.netl.doe.gov/publications/proceedings/01/hybrids/ hybrid01.html. Accessed June 20, 2003. e) Levelized cost of energy estimates (excluding the Production Tax Credit) reported in Energy Commission, 2003, ***Renewable Resources Development Report***, Staff Draft, Appendix D. Estimates were prepared by Navigant Consulting, Inc., subcontractor to XENERGY, Inc., Technical Assistance Contractor for the Renewable Energy Program (Contract No. 500-01-036).

Regarding the projected costs for 2017, the levelized cost comparisons presented are from the project owner perspective, except for PV which is presented from the building owner perspective and anaerobic digester gas from animal wastes, which is evaluated from both the developer and farmer perspectives. The cost comparisons include state and federal tax incentives except the Production Tax Credit, but not including any state rebates resulting from PGC funds. It is important to note that developer economics alone do not determine the actual price at which resources are sold in the market through Power Purchase Agreements or other contract vehicles. The price of any specific resource is based upon a myriad of factors, including dispatchability, ability to follow loads, and availability and prices of competing supplies.

New and Proposed Renewable Facilities

The portion of technical potential for renewable energy development that has been proposed for development is affected by the price buyers are willing to pay. Many of the contract price details of recent solicitations for procuring renewable energy are confidential. However, details of the recent renewable procurement contracts signed by PG&E in partnership with DWR have been made available to the public.[60] The company name, resource type, MW, capacity payments, and energy price for these contracts are shown in **Table 5-2**.

Table 5-3 summarizes recent proposals for renewable generation in California and the other WECC states. To identify recent development proposals, staff reviewed publicly available data on expected output (GWh/year) from proposed projects for wind, geothermal, biomass and solar thermal from IOU and municipal electric utility solicitations for new renewable electricity.[61]

Wind energy dominates proposed additional renewable energy facilities throughout the WECC region. Over 50,000 GWh/year of primarily wind energy have been proposed in Washington and WECC states adjacent to California. According to data available for this study, facilities expected to generate about 6,200 GWh/year have been proposed in outer tier WECC states.

Table 5-2
PG&E/DWR Interim Procurement Contract Prices

Company	Product (resource type)	Quantity (MW)	Capacity ($/kW-Year)	Energy Price ($/MWh)
NDC Consulting	Biomass	6	$0	$50
Wheelabrator	Biomass	3	$30	$47
Calpine	Geothermal (shaped)	40	$250	$17.12
Calpine	Geothermal (shaped)	70	$250	$17.12
Total		**119**		

Source: California Department of Water Resources. http://wwwcers.water.ca.gov/contracts.html. Accessed June 11, 2003.

Table 5-3
Recent Proposals for Renewable Generation

Technology	California (GWh/year)	Inner Tier WECC (GWh/year)	Outer Tier WECC (GWh/year)	Total (GWh/year)
Wind	17,021	24,893	5,270	47,184
Geothermal	6,961	2,249	867	10,077
Biomass and Biogas	2,146	175	-	2,321
Solar CSP	263	110	-	373
TOTAL (rounded)	26,390	27,430	6,135	59,955

Sources: the Energy Commission's New Renewable Resources Account database, California Power Authority Letters of Intent, Northern California Power Agency, Southern California Public Power Authority Request for Proposals (RFP), Bonneville Power Authority Transmission Information database, the Sierra Pacific RFP, and Foresight Energy's ongoing review of press releases and other data sources.

In addition to the technologies shown in **Table 5-3**, staff expects installed PV generation capacity to continue to grow rapidly in California over the next few years.

Another possible avenue for a substantial portion of the RPS and/or the accelerated RPS goal is re-powering of existing wind facilities. A benefit of this approach is the fact that existing or upgraded transmission lines could be utilized. Also, environmental impacts of re-powering may be less disruptive than impacts associated with constructing new facilities. The federal Production Tax Credit is an important part of the economics of wind development. In California, most wind facilities are selling power to IOUs under long-term PURPA contracts. Currently, federal law requires that these existing contracts be renegotiated or amended for re-powered wind projects to benefit from the Production Tax Credit.

Publicly available proposals should be reviewed after RPS solicitations, to provide an updated and empirically grounded indication of the amount and mix of technology likely to be proposed under RPS guidelines.

Expected Trends Given RPS Requirements

SB 1078 establishes a RPS program that requires retail electricity sellers, such as IOUs, to increase the renewable content of their electricity deliveries by one percent per year over a baseline level to be determined by the CPUC within certain cost constraints. Retail sellers must meet a target of 20 percent renewable content in their electricity portfolio by December 31, 2017.

Using the demand forecast in the ***Electricity and Natural Gas Assessment Report***, staff estimated the amount of renewable electricity (GWh/year) needed to reach California's RPS and the amount needed to reach the accelerated RPS recommended in the ***Energy Action Plan***. **Table 5-4** shows the increments calculated in the ***Preliminary Renewable Resource Assessment*** (PRRA) for 2005 and 2008 to reach the total of 60,980 GWh/year from renewable energy by 2017.[62] In order to meet their requirements under RPS, the PRRA estimates that IOUs and ESP/CCAs will need to procure an additional 21,200 GWh/year on top of the amount of energy (GWh/year) identified for the estimated 2001 baseline and publicly available information regarding results from the Interim Procurement. These numbers are approximations developed for the use of transmission planning. Actual timing and magnitude of renewable energy development will vary from the amounts shown here. **Table 5-4** updates the information used to prepare Appendix G of the ***Electricity Infrastructure Assessment*** (Pub. 100-03-007F, May 2003).

Under SB 1078, the CPUC has authority to determine implementation procedures for ESP/CCAs. The CPUC will issue rulings regarding this topic in a new RPS proceeding yet to be opened. SB 1078 requires ESP/CCAs and Publicly Owned Electric Utilities to reach a level of renewable energy equivalent to 20 percent of retail sales by 2017. Publicly Owned Electric Utilities will develop and implement their own programs, and the Energy Commission intends to provide assistance as needed.
ESP/CCAs provided approximately 10,392 GWh of California's retail electricity sales in 2001. Of this amount, the Energy Commission estimated that approximately 7.2 percent, or 745 GWh, came from renewable resources in 2001. To reach their obligations under SB 1078, the Energy Commission estimates that ESP/CCAs will need about 3,840 GWh/year in addition to estimated 2001 levels and estimated projects planned for the near term.

Table 5-4
Estimated Amount of Renewable Electricity (GWh/year) Needed to Reach California's RPS by 2017

	2001 baseline and interim procurement*	Added by 2005	Added by 2008	Added by 2017	Total Added by 2017	20 percent of 2017 sales
Retail seller	**GWh/yr**	**GWh/yr**	**GWh/yr**	**GWh/yr**	**GWh/yr**	**GWh/yr**
PG&E	8,358	1,253	2,916	5,353	9,522	17,880
SCE	11,908	756	2,209	2,158	5,123	17,031
SDG&E	1,062	0	319	2,402	2,721	3,783
All ESP/CCA	1,865	531	859	2,447	3,837	5,702
Sub-total	23,193	2,540	6,303	12,360	21,203	44,396
Rest of State**	7,177	1,693	2,584	5,130	9,407	16,584
Total (rounded)	**30,370**	**4,230**	**8,890**	**17,490**	**30,610**	**60,980**

*Based on estimated 2001 baseline and publicly available information on the Interim Procurement. This analysis assumes that all of the "obligated entities" identified in the table above procured an additional one- percentage point increase in their renewable baseline between 2001 and 2003. **Rest of state includes Rural Cooperatives, IOUs other than PG&E, SDG&E, and SCE, and publicly owned electric utilities. These entities are not specifically required to achieve 20 percent renewable generation.

Table 5-5
Estimated Amount of Renewable Electricity (GWh/year) Needed to Accelerate California's RPS to 2010 (20 percent of Retail Sales in 2010)

	2001 baseline and interim procurement*	Added by 2005	Added by 2008	Added by 2010	Total Added by 2010	20 percent of 2010 sales
Retail seller	GWh/yr	GWh/yr	GWh/yr	GWh/yr	GWh/yr	GWh/yr
PG&E	8,358	1,823	3,552	2,417	7,792	16,150
SCE	11,908	756	2,209	374	3,339	15,247
SDG&E	1,062	157	1,264	883	2,304	3,365
All ESP/CCA	1,865	958	1,327	952	3,237	5,102
Sub-total	23,193	3,694	8,351	4,626	16,672	39,865
Rest of State**	7,177	2,429	3,374	2,321	8,124	15,301
Total (rounded)	30,370	**6,120**	**11,730**	**6,950**	**24,800**	**55,170**

*Based on estimated 2001 baseline and publicly available information on the Interim Procurement. This analysis assumes that all of the "obligated entities" identified in the table above procured an additional one-percentage point increase in their renewable baseline between 2001 and 2003. **Rest of state includes Rural Cooperatives, IOUs other than PG&E, SDG&E, and SCE, and publicly owned electric utilities. These entities are not specifically required to achieve 20 percent renewable generation.

The ***Energy Action Plan*** sets a goal of an accelerated RPS, reaching 20 percent of retail sales by 2010 rather than 2017. **Table 5-5** shows the statewide 2005, 2008, and 2010 energy requirements to meet the ***Energy Action Plan*** goal.

Plausible Scenarios for RPS and Accelerated RPS

Table 5-6 identifies a plausible scenario to meet estimated statewide RPS demand with renewable energy projects in California that have already been proposed for construction or re-powering, plus development of some technical potential in California that has not yet been proposed and is not online. Most of the 2017 requirement could be met from the set of resources that have been proposed for development. This scenario assumes that all renewable energy facilities utilized to meet California's RPS are located in California. The mechanisms and expected magnitude for out-of-state participation will be known with greater certainty later this year. **Table 5-7** identifies a plausible scenario to meet estimated demand for an accelerated statewide RPS.

BENEFITS AND CHALLENGES ASSOCIATED WITH RENEWABLE ENERGY

Renewable energy resources have the potential to contribute to employment, energy diversity and security, public health, and environmental quality, including efforts to address climate change. Efforts to lay the groundwork for DG also raise important benefits and challenges for California's electricity system.

The benefits and challenges to California's electricity system vary by resource type, because renewable energy resources provide different products. The general characteristics (e.g., dispatchability, intermittency) and timing (e.g., baseload, peaking) differ from resource to resource. Furthermore, specific projects may incorporate designs (e.g., innovative wind turbine design, energy storage) that cause products to differ within renewable resource types.

EMPLOYMENT

Increasing California's reliance on renewable energy resources can create employment opportunities in California, other WECC states, and overseas. An overview of the scale, location, and type of employment opportunities that are likely to result from California's RPS are described below.

Provided the barriers and issues to achieving the RPS are addressed, the RPS is expected to stimulate an increase in economic activity in California's renewable industry. While an estimate of the net effect of this increase is not attempted here, the following data provides some indication of job growth associated with RPS.

In a 2001 report for the Energy Commission, the Electric Power Research Institute (EPRI) estimated the employment rates (jobs/MW) for construction and operation and maintenance jobs for a range of renewable energy resource types. For construction-related jobs, the estimates were as follows: wind was 2.57 jobs/MW, geothermal was 4.00 jobs/MW, solar PV was 7.14 jobs/MW, and biomass was 3.71 jobs/MW. For operation and maintenance, the estimates were as follows: wind 0.29 jobs/MW, geothermal 1.67 jobs/MW, solar PV 0.12 jobs/MW, and biomass 2.28 jobs/MW. Assuming these employment rates decrease over time due to gains in expertise and efficiency, a 2003 report from Environment California Research and Policy Center (affiliated with California Public Interest Research Group - CalPIRG) estimated in-state construction person-years to be about 4,800 and in-state operation and maintenance person-years to be about 118,000 over the life of the plants built to meet the RPS. In addition, Environment California estimated that the RPS would lead to about 78,000 person-years for construction of renewable energy facilities overseas.[63]

Table 5-6
California Statewide Supply Scenario for RPS by Physical Location – in GWh/Year (Resources Located in California)[64]

		Additional Supply to Meet Estimated Statewide RPS Renewable Energy Demand			
		Proposed Projects	2005	2008	2017
Physical location	Additional RPS Demand		4,230	8,890	17,490
	County/Resource				
PG&E	Siskiyou/geothermal	1,480	-	780	700
	Solano/wind	1,230	660	310	260
	Modoc/geothermal	830	-	-	830
	Alameda/wind	645	150	340	155
	Other/wind	-	-	-	-
	Other/geothermal	-	-	-	-
	Other/solid biomass	230	-	175	380
	Other/LFG-digester	310	150	160	-
	Other/CSP	-	-	-	-
	Subtotal PG&E	**4,725**	**960**	**1,765**	**2,325**
IID	Imperial/geothermal	1,890	945	475	1,500
	Imperial/solid biomass	560	-	-	560
	Imperial/LFG-digester	-	-	-	-
	Imperial/wind	-	-	-	-
	Imperial/CSP	-	-	-	-
SCE	Kern/wind	11,620	875	4,320	7,250
	Mono/geothermal	2,760	-	395	2,365
	Riverside/wind	1,620	615	580	425
	San Bernardino/wind	280	150	120	950
	San Bernardino/ CSP	265	-	-	395
	Los Angeles/solid biomass	350	-	350	-
	Los Angeles/LFG-digester	210	110	100	-
	Los Angeles/wind	305	310	-	965
	Other/wind	90	-	-	90
	Other/geothermal	-	-	-	-
	Other/solid biomass	10	-	10	-
	Other/LFG-digester	270	110	110	50
	Other/CSP	-	-	-	-
	Subtotal SCE and IID	**20,230**	**3,115**	**6,460**	**14,550**
SDG&E	San Diego/wind	1,225	-	610	615
	San Diego/solid biomass	-	-	-	-
	San Diego/LFG-digester	210	155	55	-
	San Diego/CSP	-	-	-	-
	Subtotal SDG&E	**1,435**	**155**	**665**	**615**
	Total Resources	**26,390**	**4,230**	**8,890**	**17,490**

In some counties/technologies, this scenario supplements proposed projects with energy from technical potential to meet estimated RPS supply needs. **Proposed projects do not add to subtotals and total due to rounding.

Table 5-7
California Statewide Supply Scenario for Accelerated RPS by Physical Location – in GWh/Year (Resources Located in California)[65]

			Additional Supply to Meet Estimated Statewide Accelerated RPS Renewable Energy Demand			
		Proposed Projects	2005	2008	2010	2017
Physical location	Additional Accelerated RPS Demand		6,120	11,730	6,950	5,810
	County/Resource					
PG&E	Siskiyou/geothermal	1,480	-	780	235	465
	Solano/wind	1,230	965	265	-	-
	Modoc/geothermal	830	-	120	120	590
	Alameda/wind	645	155	415	15	60
	Other/wind	-	-	-	-	-
	Other/geothermal	-	-	-	-	-
	Other/solid biomass	230	175	70	-	310
	Other/LFG-digester	310	225	85	-	-
	Other/ CSP	-	-	-	-	-
	Subtotal PG&E	**4,725**	**1,520**	**1,735**	**370**	**1,425**
IID	Imperial/geothermal	1,890	945	710	945	315
	Imperial/solid biomass	560	-	350	210	-
	Imperial/LFG-digester	-	-	-	-	-
	Imperial/wind	-	-	-	-	-
	Imperial/ CSP	-	-	-	-	-
SCE	Kern/wind	11,620	1,210	5,855	4,370	1,010
	Mono/geothermal	2,760	-	790	790	1,180
	Riverside/wind	1,620	765	855	-	-
	San Bernardino/wind	280	150	185	-	890
	San Bernardino/ CSP	265	-	-	265	130
	Los Angeles/solid biomass	350	-	350	-	-
	Los Angeles/LFG-digester	210	180	30	-	-
	Los Angeles/wind	305	305	110	-	860
	Other/wind	90	90	-	-	-
	Other/geothermal	-	-	-	-	-
	Other/solid biomass	10	-	10	-	-
	Other/LFG-digester	270	185	85	-	-
	Other/ CSP	-	-	-	-	-
	Subtotal SCE and IID	**20,230**	**3,830**	**9,330**	**6,580**	**4,385**
SDG&E	San Diego/wind	1,225	610	615	-	-
	San Diego/solid biomass	-	-	-	-	-
	San Diego/LFG-digester	210	160	50	-	-
	San Diego/ CSP	-	-	-	-	-
	Subtotal SDG&E	**1,435**	**770**	**665**	**-**	**-**
	Total Resources	**26,390**	**6,120**	**11,730**	**6,950**	**5,810**

In some counties/technologies, this scenario supplements proposed projects with energy from technical potential to meet estimated RPS supply needs. **Proposed projects do not add to subtotals and total due to rounding.

Employment opportunities in California related to renewable energy require a range of scientific, technical, and marketing expertise. The following provides an overview of the work tasks related to renewable energy development in California:

- Analysis of available wind, geothermal, biomass, solar, ocean wave, and small hydroelectric resources;
- Design of utility scale and DG renewable energy facilities;
- Development, marketing, financing, permitting, environmental assessment, and siting of facilities;
- Construction and installation of renewable energy electric generation facilities; and
- Operation and maintenance

California's RPS is designed to encourage a steady stream of renewable development, operation, and maintenance, with new construction continuing through 2017. The accelerated RPS goal in the ***Energy Action Plan*** would increase new construction at a faster rate, especially for renewable resources intended to meet San Diego Gas & Electric's RPS requirements. Following the construction phase, employment opportunities are likely to shift to operation and maintenance, along with some continued development and re-powering of renewable resources.

The physical location of the plants will be decided through the RPS procurement solicitations. The plausible scenarios for renewable resource development included in this chapter (see **Tables 5-6 and 5-7**) emphasize resources located in California, but many resources used to meet the RPS may be located out of state. Within California, many of the possible opportunities for plant construction and operation and maintenance employment are likely to be located in relatively rural areas. Many of the out-of-state projects submitted in response to recent publicly available bid solicitations are located in Washington, Oregon, and Nevada.

Opportunities for employment in business development, marketing, and financing related to renewable energy are likely to be located in urban centers near customers, clients, and regulatory agencies.

Energy Diversity and Security

Increasing California's reliance on renewable energy resources can contribute to energy diversity and economic security by reducing reliance on natural gas. The Energy Commission staff utilized a market simulation model (MarketSym^{TM}) to evaluate the uncertainties that may affect natural gas and coal demand and put stress on the WECC electricity and natural gas infrastructure system. To evaluate the impact of renewable energy in isolation from other changes in the WECC electricity system (including areas of Canada and Mexico), an accelerated RPS scenario, RPS scenario, and a pre-RPS trends scenario were simulated holding the load adjustments attributed to energy efficiency and other DSM efforts constant. These scenarios were simulated in addition to the scenarios summarized in the ***Electricity Infrastructure Assessment***, which is part of the ***Electricity and Natural Gas Assessment Report*.** This analysis compared only energy outputs; it did not examine the system benefits and costs of varying quantities and/or types of resources. The results from these scenarios are suggestive only.[66]

The renewable energy simulations suggest that meeting the RPS for the IOUs may displace 2.5 percent of annual demand for natural gas in electricity generation that would otherwise occur by the WECC in 2013. Accelerating the RPS to 20 percent of retail sales by 2010 (as modeled) practically doubles this effect, raising it to a reduction of about 5 percent.

As noted in the ***Electricity Infrastructure Assessment***, natural gas prices have fluctuated widely over the past 3 years. Natural gas- fired generation usually uses financial hedges to limit price risk at some cost. Many renewable energy resources have zero or small fuel costs, in comparison to most conventional generation resources. Renewable energy resources are able to sign fixed-price contracts that do not vary based on the price of natural gas. An increasing proportion of these fixed-price contracts, as envisioned through the RPS, should require less financial hedging to mitigate price risk. The degree to which this occurs depends on the specific contract arrangements that are established through the RPS. Reducing the system exposure to price risk through fixed price renewable contracts may cost more or less than addressing the same risk with financial hedging of natural gas prices, depending on the costs and other benefits of these contracts.

Ratepayer prices for renewable energy will be affected by the expectations for natural gas at the time of procurement, since pricing for RPS energy generation is a combination of a "market price referent" (e.g., natural gas combined cycle plant) and a PGC payment. PGC funds will be used to bridge the gap between the market price referent and the bid price for the winning RPS bids.

Natural gas prices may rise or fall, however, customers would be somewhat insulated from natural gas price volatility. Details regarding contract terms for RPS are expected to be decided by the CPUC as part of the RPS proceeding before the end of 2003.

A 2003 study from Lawrence Berkeley National Laboratory, ***Accounting for Fuel Price Risk***, recommends the use of forward natural gas prices rather than gas price forecasts to compare renewable energy generation to natural gas-fired electricity generation.[67] The report notes that gas price forecasts provide no assurance that actual prices will reflect forecasted prices. In contrast, contracts for the forward prices for natural gas are designed to ensure delivery of natural gas for the next 2-10 years at prices determined today, with a value for uncertainty built into the contracted price. The report argues that the price stability that is provided by the forward prices is a better approximation of the price stability offered by renewable energy than natural gas forecasts and should be the preferred natural gas comparison to renewable energy. Based on data from 2000-2003, the report finds that gas forward prices were higher than forecasted by 0.4 cents/kWh on average. The report cautions against extrapolating this figure, as the data used may not be indicative of general trends. Instead, the report argues for the use and extension of forward price curves in gas-price forecasts and for the collection of fixed-price long-term gas-fired electricity bids from generators. The report also notes that forward prices for natural gas do not capture the reduced credit risk associated with the fixed-price renewable contracts relative to natural gas contracts of similar duration. Also, it does not capture the value of the potential for increased renewable energy to reduce demand for gas-fired electricity generation in the future, which could reduce the price of natural gas.

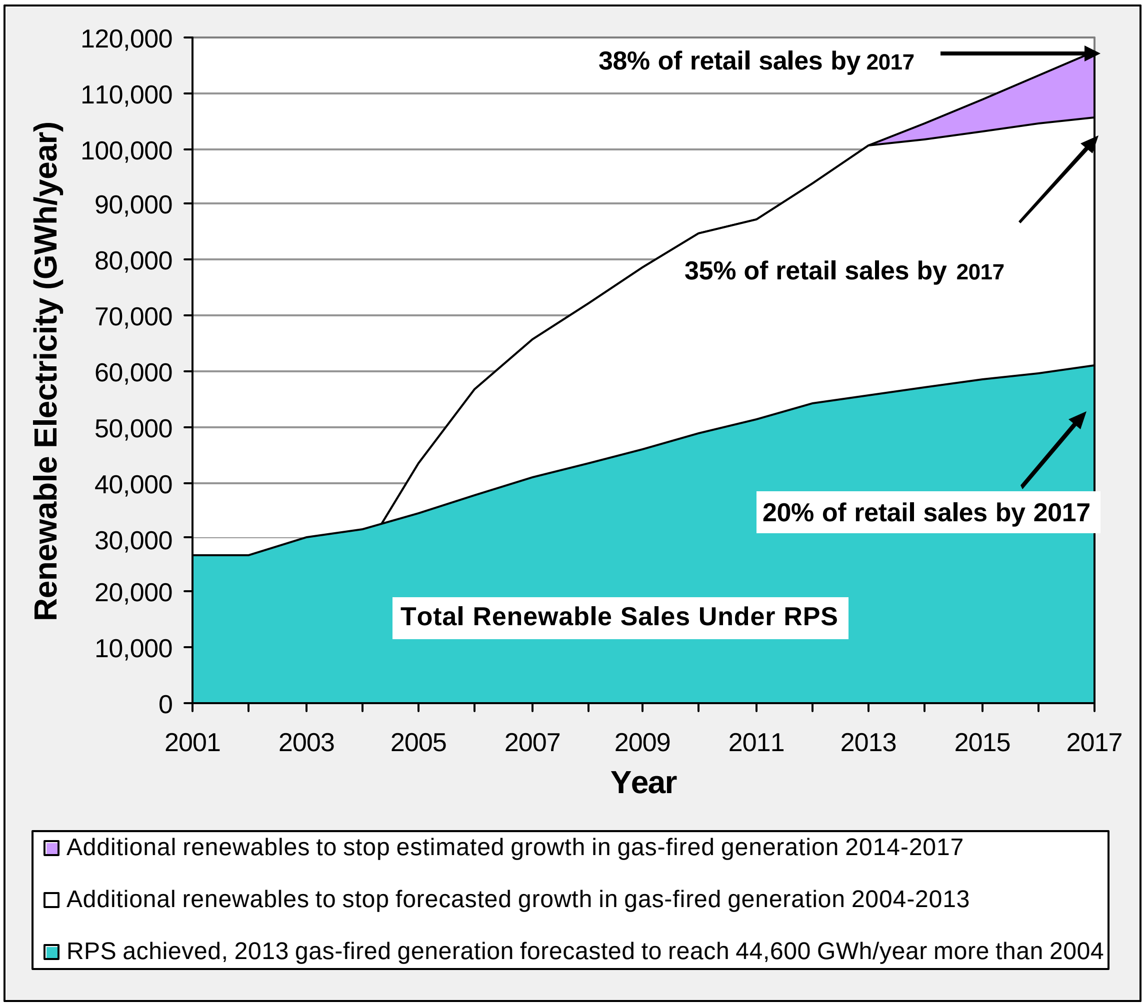
Beyond market-related fluctuations, electricity deliveries could also be disrupted due to major earthquakes, wildfires, severe weather, or man-made disasters. Any central station form of electricity generation is subject to transmission outages, such as those caused by man-made or natural disasters. DG located on-site for critical service centers can be of assistance during interruption of electric transmission grid service. Because they can be installed quickly in a wide range of locations and can operate independent of interconnection to the transmission grid, small on-site PV systems (e.g., 2 kW) have been used in disaster response to power such essential services as street lighting, communications, medical services, traffic signals, and gasoline pumps at service stations. An important attribute of PV systems is that unlike many emergency generators, they do not require gasoline or other liquid fuels to operate. Such fuels may be difficult to locate during a disaster or its aftermath.

The baseline scenario described in the ***Electricity Infrastructure Assessment*** includes RPS achievement by 2017 and current funding levels of energy efficiency/DSM measures. Results from the scenario show an increase in gas-fired generation in California from about 90,700 GWh in 2004 to about 135,300 GWh in 2013, a growth of about 44,600 GWh.[68] This amount is equivalent to about 16 percent of estimated retail sales for California in 2013 (286,100 GWh). Data collected for the PRRA indicate that there is enough technical potential in California, Washington, and adjacent WECC states, to meet this need with renewable energy. If renewable energy could be used to replace estimated growth in gas-fired generation from 2004-2017, the total amount of renewable energy by 2017 would reach about 38 percent (See **Figure 5-3**). This would make renewable energy the largest source of electricity generation in California.

On July 3, 2003 CPUC Commissioner Susan P. Kennedy provided direction and scope for further rulemaking regarding energy efficiency (R.01-08-028), including a proposal that California meet 100 percent demand growth with energy efficiency, demand response, and renewable resources. **Figure 5-3** shows an upper bound on the potential role of renewable energy should this proposal be implemented.

While there are sufficient potential renewable energy resources to furnish such a large fraction of the annual kWh used by California consumers, other essential features of the electricity system need to be taken into account. These load-following and local delivery characteristics require that the system have electricity when it needs it and that over-generation be minimized. It also requires that an integrated transmission system be able to get supply to load. The design and operation of an electric generating system must incorporate multiple considerations, including the various needs for baseload versus peaking power, local voltage support, spinning reserve and the load-following flexibility that gas plants traditionally provide. Therefore, pursuing a goal of 38 percent renewable energy requires careful design and implementation, taking into account the cost and operational implications of developing such a system.

Figure 5-3
Hypothetical Replacement of Forecasted Growth in Gas-Fired Generation with Renewable Energy (2004-2017)



Environmental and Public Health Impacts

Californians prize their environment, and public agencies have worked hard to protect the air, water, and land resources in the state, but environmental problems associated with energy use in California remain of concern. One remaining significant issue is emissions of GHG - contributors to global climate change - from fossil fuel combustion for electricity generation. As reported in ***Climate Change in California*** (publication no. 100-03-017D), climate change represents a significant risk to California as a result of a warming and increasingly variable climate. The signs of a global warming trend continue to become more evident and much of the scientific debate is now focused on expected rates at which future changes will occur. Rising temperatures and sea levels and changes in hydrological systems are threats to California's economy, public health, and environment.

Generation of electricity from renewable energy rather than fossil fuels can reduce CO_2 and other GHG emissions associated with climate change. Relative to a projection of pre-RPS trends in CO_2 emissions, the MarketSym™ simulations suggest that achieving the IOU RPS requirements could reduce annual CO_2 emissions by about 38 million tons from gas-fired and coal-fired electricity sector in the WECC by 2013. The model suggests that achieving the RPS by 2010 could reduce annual CO_2 emissions by about 62 million tons by 2013. This is equivalent to estimated annual CO_2 emissions from more than 6 million automobiles.[69]

The accelerated RPS/high DSM scenario reported in the ***Electricity Infrastructure Assessment***, which assumes IOU RPS is achieved in 2010 and DSM funding is doubled, suggests that annual CO_2 emissions from natural gas and coal used to generate electricity in California may be reduced by about 60 million tons CO_2 by 2012.

Further steps could be undertaken to reduce emissions of GHGs through the transportation sector, energy efficiency and demand-side management, and renewable energy resources in the electricity sector. The following is a list of possible renewable energy actions toward this end:

- Reduce fuel costs at biomass power plants by accounting for the costs of alternative disposal of the fuels (e.g., open-field burning).

  An interagency task-force of relevant agencies, such as the California Integrated Waste Management Board, California Department of Forestry (CDF), California Air Resources Board (ARB), and Air Quality Management Districts (AQMD), and others should be constituted to re-examine methods of reducing fuel costs and volatility of costs at biomass facilities. Potential measures to consider include:

  - Establish air-quality credits for avoiding open-field burning in central valley farms,
  - Enact feebates or tax-credits for construction and logging industries to foster delivery of waste product to biomass facilities, and
  - Identify a range of measures to be included in forestry management plans that would lead to increased delivery of waste products to biomass facilities.

- Increase purchases of renewable energy by state and local governments

  State and local governments, as consumers, can increase their demand for renewable energy in their electricity purchases and other policies. They can also encourage other institutions to develop and implement market-based strategies and programs. Specific actions include:

  - Expanding green pricing programs run by municipal utilities,

- Promoting new customer aggregations and community wind development,
- Identify measures that will increase government purchases of renewable energy, and
- Incorporating renewable technologies into state and local security plans and structures.

- Increase opportunities for renewable DG and agricultural use of renewable energy.

  Beyond state and local programs that provide financial incentives for installing renewable energy and DG, additional actions are needed to continue to grow this vital industry in California. These actions include:

  - Providing technical and financial assistance to agricultural producers and processors to shift their energy sources to renewable sources such as biofuels, PV, concentrating solar power, and wind.
  - Develop incentives for food processors and other industries with significant organic wastes to use digester gas self-generation.
  - Continue to remove barriers to renewable self-generation from local codes and interconnection requirements.
  - Incorporate, as appropriate per PRC section 25402, renewable DG technologies in energy standards for new building construction.
  - Expand net metering to include broader biogas generation opportunities.

In addition to CO_2, staff also simulated the reduction in NO_x emissions that may result from implementation and acceleration of IOU procurement for the RPS. It is important to note that, in California, NO_x emissions from the generation of electricity from natural gas are well controlled. As stated in the ***Electricity and Natural Gas Assessment Report***, combustion-fired electric generation contributes a relatively small portion of the emissions of NO_x (three percent) in California. Further additions of new efficient combined-cycle power plants, new renewable power plants, and energy efficiency and load management programs in the coming years will continue this trend.

To estimate the public health benefits associated with IOU procurement for California's RPS, Energy Commission staff focused on reduced emissions of NO_x and reduced utilization of coal-fired electric generation plants. The scenarios simulated to isolate the contribution of IOU procurements for the RPS to security, public health, and environmental concerns suggest that achieving the RPS could reduce annual NO_x emissions from natural gas and coal in the WECC by 20,000 tons by 2013. Achieving the RPS by 2010 could reduce annual NO_x emissions in the WECC by 31,500 tons by 2013. This NO_x reduction builds upon the gains made in recent years to reduce NO_x emissions in the electricity sector. Additional information regarding public health effects of California's electricity generation system are reported in the ***Electricity and Natural Gas Assessment Report***.

Environmental Issues Associated with Renewable Energy

The ***2003 Environmental Performance Report*** indicates that environmental challenges of gas-fired generation in California include the need to reduce emissions of GHG such as CO_2, make further NO_x and PM10 reductions in air basins with air quality problems, reduce NO_x emissions from boiler and combustion turbine facilities used to meet peak energy demand, reduce the use of once-through water cooling, and reduce nitrogen deposition in sensitive ecological areas. Appendix D of the ***2003 Environmental Performance Report*** also describes environmental challenges associated with large hydroelectric generation. Renewable energy resources can reduce the use of gas-fired generation in California and replace energy from decommissioned hydroelectric, thereby reducing the environmental impacts associated with those energy resources. Increasing the use of renewable energy requires attention to a different set of environmental impacts, many of which can be handled with existing technologies.

Full implementation and acceleration of California's statewide RPS goals would result in benefits including lowered GHG emissions, increased fuel diversity, and reduced criteria emissions. On the other hand, like any new resource or infrastructure development, other environmental issues are raised. For example, The ***2003 Environmental Performance Report*** notes that there is a potential need for new transmission connections for renewable energy located in rural areas, which may impact land use.

Other renewable energy resources (e.g., roof-top PV, digester gas) are located in populated areas in proximity to existing transmission lines. Re-powering existing renewable resources with newer, more efficient energy generation equipment also offers the opportunity to utilize existing transmission infrastructure. The Energy Commission's PIER program is currently studying the impact of new generation on transmission congestion. Preliminary results indicate that added generation reduces the need to add or upgrade transmission infrastructure in some cases, but in other cases it aggravates congestion.

The key environmental issue associated with **wind energy** is the impact of the turbines and associated transmission on resident and migratory bird populations, especially raptors, and their habitat. The wind turbines in the Altamont Pass Wind Resource Area are especially problematic, due to prey density, terrain features, and wind turbine placement.[70] Research efforts are underway to identify optimal placement of wind facilities and equipment design changes to minimize interaction with birds.[71] Wind energy procurement solicitations can also create incentives to reduce wind energy-related avian deaths. For example, the Bonneville Power Administration 2001 *Request for Wind Project Proposals* requires the use of "state-of-the-art measures to minimize potential avian mortality, noise, and visual impacts of the facility."[72]

For **geothermal**, the key environmental and public health issues are land use, potential groundwater and/or surface water contamination, and emissions of hydrogen sulfide

(0.0145 kg/MWh), dissolved solids, and carbon dioxide (45 kg/MWh).[73] Many geothermal resources in California are located in areas valued as wilderness, sacred areas, or recreation areas. Constraints on building an electricity generation facility in such areas (and bringing transmission to the facility) make some geothermal resources infeasible for development. Land subsidence may also be a concern, depending on the structure of the geothermal resource.[74]

Development of geothermal resources may pose a risk of groundwater and/or surface water contamination, depending on the technology utilized to harness the geothermal energy (e.g., open-loop or closed-loop system) and the care with which geothermal fluids are managed. In order to avoid groundwater contamination, best practices must be used in geothermal well construction, and disposal of water and wastewater used in geothermal energy generation. In many cases, water and wastewater is re-injected into the geothermal resource to avoid depleting the geothermal resource. At the Geysers geothermal energy facility in Lake County, treated municipal wastewater is being injected into geothermal wells as well.[75]

The main environmental problems associated with **biomass** are emissions associated with transportation of biomass to the electricity generation facility, potential damage to forests, wildlife, and watersheds from harvesting of forest products, and emissions of NO_x, Sulfur Dioxides, Carbon Monoxide, and particulate matter. A number of efforts are underway to address these concerns. For example, distributed generators are being developed to use biomass in cogeneration applications, which could reduce the distance that biomass is transported to produce electricity.[76] Rulemaking proceeding R.03-03-015 at the CPUC is considering whether to create an incentive to IOUs to promote sustainable management of watersheds surrounding their hydroelectric facilities. To be eligible for the RPS, the following requirements for wood and wood wastes used for biomass electricity generation: the wood and wood wastes have been harvested according to an approved timber harvest plan, they have been harvested for the purpose of forest fire fuel reduction or forest stand improvement and they do not transport insect, or disease nests outside zones of infestation.[77] Where harvesting practices are sustainable, biomass can function as a waste disposal process that provides electricity as a marketable output.

Control technologies are available to reduce criteria air pollutant emissions from electricity generation fueled by biomass. However, emissions from biomass combustion cannot be reduced below emissions from natural gas electricity generation. CO_2 emissions from biomass electricity generation are considered to be zero, as the plant matter used to generate electricity releases the same amount of CO_2 that it consumed in photosynthesis.[78]

Concentrating Solar Power electric generation that operates without a fossil fuel component has few environmental issues beyond the amount of land that is required (5-10 acres /MW) and, in the case of trough and tower power technology, water requirements (2-4 cubic meters of water per MWh generated). Dish/Stirling engines do not require water for operation, other than a small amount for mirror cleaning. In solar trough systems, the oil used for heat transfer (Monsanto Therminol VP-1) is a hazardous material according to California standards. On-site bio-remediation technology is available to decontaminate soil affected by a spill of this material.[79] Parabolic trough natural gas hybrid systems operating as qualifying facilities under PURPA may not generate more than 25 percent of total energy from natural gas.

The greatest environmental and health risk associated with **photovoltaic panels** is accidental occupational exposure to potentially toxic substances (e.g., cadmium, lead solder). Cadmium is a carcinogen (lung and prostate) and can cause damage to kidneys and bone if exposure continues over a long period of time.[80] Lead can damage the nervous system, kidneys, and reproductive system. In children, lead can cause problems in mental and physical development, anemia, or brain damage.[81] Drawing on techniques used in the manufacture of semiconductors, the U.S. industry follows exacting procedures to guard against worker exposure. Workers' health is further monitored through medical tests of exposure to known hazards in the work place. Final disposal of PV panels could pose a risk as well, although PV panels are designed to encapsulate toxic materials. To further minimize this risk and maintain a low-cost supply of materials, the U.S. industry plans to recycle PV panels for the manufacture of new panels.[82]

Although **ocean wave** energy conversion is not widely commercialized, it is included as one of the renewable energy generation technologies eligible for support through the Energy Commission's Renewable Energy Program, provided that related requirements in SB 1038 and SB 1078 are met.[83] Two MW of ocean wave energy conversion systems are in operation worldwide. Quite a variety of technologies for converting ocean wave energy to electricity are in the research and development stage, and the technical potential for wave energy in California is substantial (7-17 MW per mile of coastline).[84] Potential environmental impacts identified to date (e.g., potential impacts to salmon, herring, and large mammal migration routes, potential impacts on coastline, build up of sediments, seabed disturbance due to moorings and sub-sea devices) suggest the need for careful environmental review and site selection when this technology becomes commercialized.[85]

New **small hydroelectric** generation (30 MW or smaller) that does not require new or increased appropriation or diversion of water may be eligible for the RPS if certain criteria are met.[86] Small hydroelectric generation can produce the following negative environmental impacts: river flows, water quality, fish passage, watershed protection, threatened and endangered species, and cultural resources.[87] Some small hydroelectric projects require FERC licenses, including a review of environmental impacts. According to the ***Environmental Performance Report***, opportunities to minimize the impact of small hydropower include the following sites: canals, water supply facilities and pipelines, incremental hydro,[88] and existing dams lacking hydropower generation.

Renewable energy resources provide some environmental and public health benefits relative to fossil fuel generation, but they also pose some risks. Attentive efforts are currently in use or under development to address many of these concerns. Continued recognition, awareness, and monitoring of environmental performance are needed to maintain and improve the net environmental benefits of the technologies listed here. However, much work needs to be done to match the products provided by renewable generation with the load- following and reliability services required by consumers. Issues raised by an expanded role for renewable energy in California's electricity sector are discussed below.

Chapter 6 of the ***Public Interest Energy Strategies*** Report lists research and development projects underway to address environmental impacts associated with wind, biomass, and biogas. Chapter 6 also lists projects that study many of the issues described below. Regarding transmission, research is underway on a strategic value analysis to identify the impact of renewable resource location on transmission congestion. Other projects include research of technologies to reduce the costs and emissions of biomass/biogas; technologies to reduce the cost of generation from low-speed wind resources; tool development, in conjunction with
CA ISO, to improve forecasts and use of intermittent renewable technologies; and the use of electricity storage technologies to address intermittency and dispatchability.

Laying the Groundwork for Expansion of Renewable DG

The U.S. DOE, Strategic Plan for Distributed Energy Resources (September 2000), set a goal of expanding DG (i.e., electricity that is generated on-site or near the place of use, typically ranging in capacity from 3 to 10,000 kW) in the United States to reach 20 percent of new electric capacity additions by 2010.[89] Recent trends in the installation of PV systems suggest that renewable DG could play an important part of the growth in DG.[90]

One of the possible benefits of DG is its potential for reducing transmission constraints. The Strategic Value Assessment funded by the PIER program is currently studying the impact of new generation on transmission congestion. Preliminary results indicate that added DG reduces the need to add or upgrade transmission infrastructure in some cases, but in other cases it aggravates congestion.

The Emerging Renewables Program has provided more than $95 million in rebates for DG using solar and wind technology. The CPUC's Self-Generation Incentive Program has allocated approximately $100 million to other projects not covered by the Energy Commission's program. The Energy Commission's PIER program also has invested over $80 million for DG research in the areas of emission reductions, reliability, and interconnection.

Further expansion of renewable DG in California faces several barriers and uncertainties, including high capital costs, siting and permitting issues, grid interconnection issues, and utility tariffs (e.g., back-up tariffs, stranded costs).

A number of activities and proceedings are underway at the Energy Commission and the CPUC to address issues related to DG in California.[91] For further information on these activities see the Energy Commission's "Distributed Energy Resource Guide," available online at www.energy.ca.gov/distgen/.

DRIVING POLICY ISSUES REGARDING CALIFORNIA'S RPS

In order to transition to the RPS vision of the state's electricity system, the following issues need to be addressed:

- Expanding the transmission system to accommodate development of renewable energy resources,
- Improving the economic viability of new renewable electricity generation facilities,
- Addressing the operational compatibility of renewable resources with the existing electricity system,
- Incorporating renewable resources into the electricity system through long-term, commitments considering the shape and amount of future demand,
- Obtaining financing for new, renewable generation, and
- Identifying activities by municipal utilities, direct service providers, and community choice aggregators to develop renewable resources

Transmission Constraints

The impact of transmission constraints on meeting California's RPS will be greatly affected by the following issues: 1) the proportion of RPS met by out-of-state renewable energy facilities; 2) capacity constraints on transmission paths connecting renewable resources to the WECC; and 3) whether the "renewable" attribute can be separated from the energy and traded in the form of a "renewable energy certificate" to meet the RPS, with the possibility that electricity paired with the renewable energy certificate may be produced by a separate non-renewable source.

Although publicly available information suggests that proposed projects in the inner tier WECC states total more than 27,000 GWh/year, the proportion of the RPS that will be met by out-of-state resources is not known. Technical potential in the outer tier states is estimated to be more than 30,000 GWh/year for geothermal and biomass and more than 2,000,000 GWh/year for wind. However, transmission constraints may limit the ability to deliver electricity from outer tier WECC states into California to meet the state's RPS.

As reported in the ***Electricity Infrastructure Assessment***, construction of new transmission lines has been stalled in California in recent years due to three issues: scope of issues considered as justification for project benefits and need, difficulties with project financing, and local opposition to environmental and property value impacts. Accelerating the RPS raises another issue: acceleration of the RPS may create pressure on utilities to develop transmission lines to export energy from areas that, under the RPS timeline (20 percent by 2017), may be expected to use the energy to meet local electricity load growth.[92]

Meeting a portion of RPS requirements through DG and/or re-powering of existing renewable energy resources may reduce the need to install new transmission lines or build transmission ahead of load growth. The Energy Commission's Public Interest Energy Research program is currently studying the impact of new generation on transmission congestion. Preliminary results indicate that added generation reduces the need to add or upgrade transmission infrastructure in some cases, but in other cases it aggravates congestion. In addition, FERC rules and pending decisions regarding the allocation of the cost of transmission upgrades is an important issue for development of renewable energy.

The CPUC in consultation with the Energy Commission will decide whether tradable renewable energy certificates will be eligible for California's RPS. In addition, the CPUC will submit to the Legislature a transmission plan for renewable electricity generating facilities by December 1, 2003. Permitting the use of tradable renewable energy certificates as a mechanism for meeting RPS obligations may help to avoid congested areas in the transmission lines carrying electricity from outer-tier WECC states to California.

Given the remaining uncertainties regarding the scale and type of participation of out-of-state renewable energy resources in California's RPS, and the pending completion of the CPUC SB 1038 transmission study, this issue should be revisited early in 2004. If tradable renewable energy certificates are not allowed and physical delivery of electricity from renewable resources is required, then California-based renewable generation facilities are likely to play a more prominent role in meeting California's RPS. If this is the case, transmission constraints in the Tehachapi and Salton Sea area may delay renewable energy procurement. Efforts to build new transmission lines and/or develop and utilize advances in transmission technology allowing greater throughput of electricity through existing lines is likely to reduce such costs and constraints in later years.

Further information regarding proposed transmission projects, including an intra-utility project proposed to address RPS needs, is available in the staff report "Upgrading California's Electric Transmission System: Issues and Solutions released with the August 8 ***Electricity and Natural Gas Assessment Report***.

Sufficiency of Public Goods Funding

The methodology for calculating market price referents (e.g., the referent for base load and the referent for peaking energy) was decided by the CPUC on June 19, 2003, but the actual market price referent for the first solicitation will not be known until after the bids have been received. As stated in SB 1078, the market price referents will not be known in advance of the solicitation to which it applies. This requirement is intended to increase the incentives for developers to submit competitive bids in the procurement process. As a result of this practice, the portion of each winning bid that is above the market price referent and eligible for supplemental energy payments will not be known in advance.

Sufficiency of PGC funding will depend on the costs of winning bids, retail sales trends, the proportion of existing renewable energy production that requires replacement, interest rates available for unexpended Renewable Resource Trust Fund (RRTF) moneys, and the market price referents above which RRTF incentives will be paid.[93]

Availability of PGC funds may be placed at risk to the extent that the state borrows money from the fund and does not pay interest on it while it is gone or does not pay it back at all. For example, in fiscal year 2002-2003, the RRTF loaned $150 million to the general fund, transferred $7 million to the general fund to help address the budget crisis, and loaned $8.9 million to the CPA. As a result, the amount available for supplemental energy payments may be reduced by the amount of interest lost over the duration of the loans and the $7 million transferred to the general fund.[94]

The rate at which the RRTF earns interest also has a financial impact on the state's ability to meet the RPS. Staff estimates that the state would earn up to $150 million in interest at 2 percent over the period 2002-2027. To the extent that the interest is lower than 2 percent, there will be less money available to make supplemental energy payments in support of the RPS.

Also, if the retail electricity sales forecast used in this analysis is low or baseline decreases, the amount of energy needed to meet 20 percent will increase. Depending on the gap between the market price referents and the winning bids, an increase in the amount of energy needed to meet the RPS could stretch the need for supplemental energy payments beyond the available funds.

At this point in time there is too much uncertainty regarding market price referents, winning bid prices, maintenance of baseline, and interest rates to determine whether PGC funds will be adequate to meet RPS, or an acceleration of RPS. As more information becomes available, this issue will be re-visited. At the conclusion of the first solicitation for RPS, the Energy Commission plans to re-evaluate the adequacy of public goods funds. If funds are not expected to be adequate, the Legislature should consider whether the funds should be increased.

LEAST COST/BEST FIT CHALLENGES

Another key issue related to expanding the role of renewable energy in California is the need to address the operational compatibility of renewable resources with the existing electricity system. A sizeable proportion of California's current electricity needs are served by continuing base load from DWR contracts. Matching RPS procurement to the shape and amount of demand already covered by long term commitments poses a challenge.

Renewable energy resources will be procured on the basis of the least cost and best fit for utility load shapes. On this topic, the CPUC RPS Phase 1 Decision (June 19, 2003) states that least cost and best fit must be treated as linked concepts in California's RPS program: "In that context the utilities should be considering the best fit that is available, which may or may not be a perfect (or even good) fit with their needs" (p. 28). Efforts to improve the cost effectiveness of dispatchable/peaker renewable energy may help to increase the likelihood that the least cost/ best fit renewable energy projects complement current and future load shapes for electricity demand served by the IOUs.

Operational compatibility

SB 1078 requires bids submitted in response to RPS solicitations to be selected according to a rank ordering of "least-cost and best-fit." The CPUC Order Initiating Implementation of the Senate Bill 1078 RPS Program (June 19, 2003) defines "best fit" as "the renewable resources that best meet the utility's energy, capacity, ancillary service and local reliability needs," with the added condition that "for the short-term, renewable generation that can operate as dispatchable or peaker power may possibly fall slightly higher on the 'procurement hierarchy.'" (p. 28)

Although historically most renewable generation has been operated as relatively non-dispatchable, must-run resources, many renewable resources can be constructed and operated with significant dispatchability. Geothermal, biomass, landfill gas, and digester gas resources can all be designed with "fuel" storage and dispatchable generation. Wind and solar technologies must generate when their "fuel" is available, and require electricity storage options (e.g., pumped hydropower, or compressed air) to achieve dispatchability.[95] Geothermal energy and run-of-river small hydropower operate as base load. If storage of electricity from these resources is available, it could potentially be used to allow dispatchable operation.

The overall average operating profile of solar energy tracks summer peak hours in California more closely than other renewable energy resources.[96] The operating profile of wind energy varies by geographic location, but where wind energy is a function of on-shore and off-shore wind patterns, wind energy is likely to be available during the morning and evening peaks of winter energy demand, but less so on the hottest summer afternoons. With storage, other renewable energy resources can be dispatched to meet peak demand as well.

The operation of renewable energy in conjunction with energy storage systems has not been economically attractive in the past.[97] To help address this issue, the Energy Commission is currently funding research in the area of cost-effective energy storage for wind and PV renewable energy sources.[98] Storage technologies under evaluation include the following: existing hydroelectric resources, batteries, superconducting magnetic energy storage, and regenerative fuel cells.[99] In addition, the Energy Commission is working with CA ISO to investigate the best use of energy storage to support expanded use of wind electricity generation.

Long Term Commitments

In response to the 2000-2001 energy crises, DWR signed long-term energy contracts. The CA ISO estimates that these contracts will provide 30 percent of the IOU's summer peak demand. Most of these contracts are set to expire in 2010 and 2011.[100] These contracts provide such a large portion of California's non-peak electricity that they may pose a challenge to the integration of renewable non-peak electricity and may be difficult to integrate into IOU and ESP/CCAs load demand. As the state's aging electricity generation stock is phased out, the proportion of retail sales served by non-renewable base load may decline, thereby creating a better niche for renewable base load electricity generation than currently available. Contract terms and flexible compliance mechanisms for RPS are under development at the CPUC. These mechanisms may allow IOUs and ESP/CCAs to bank or delay acquisition. This could be used to help address the need to fit renewable energy to utility load shapes. This will be especially important in the acceleration of RPS, which is estimated to entail an additional 17,850 GWh/year of electricity for the entire state from renewable energy resources by 2008, before most of the DWR contracts are set to expire.

Financing for New Renewable Generation

Financing for new renewable generation is affected by IOU creditworthiness, uncertainty regarding federal and state incentives for renewable energy in the California electricity sector, but conditions are improving. Participation in solicitations for the interim procurement of renewable energy held by PG&E, SCE, and SDG&E in 2002 and other recent solicitations is an encouraging indication of the interest in the financial community to participate in development of renewable energy. Several institutional and regulatory events in the last year will further assist in financing renewable energy generation.

At the federal level, the Production Tax Credit provides a tax credit for new projects for the first 10 years of energy production in the amount of 1.5 cents/kWh, adjusted for inflation. Re-powered projects can benefit from this tax credit under certain conditions, such as renegotiating or amending their existing long-term contracts. Renegotiation of such contracts has not occurred significantly since this provision was added to the Production Tax Credit law, which has limited re-powering in California. Unless extended by Congress, this tax credit is scheduled to expire December 31, 2003.

Another federal incentive, the Renewable Energy Production Incentive provides annual payments of 1.5 cents/kWh to qualifying renewable energy facilities beginning operations between October 1, 1993 and September 30, 2003 that are owned by state, local government entities, and not-for-profit cooperatives. Absent reauthorization, Renewable Energy

Production Incentive payments will not be available for development of new renewable energy resources owned by state or local government or not-for-profit cooperatives. This may have a negative impact on the availability of financing for some new renewable generation projects.

Within the state, steps are being taken to improve the creditworthiness of PG&E and SCE. This will reduce the cost of financing development of renewable energy in California. In addition, progress has been made to establish the rules that are required to launch California's RPS, including a procedure for procuring resources for RPS before all of the rules are set in place. However, uncertainty related to transmission congestion and integration costs may still be affecting the cost of financing new renewable energy projects.[101]

The RPS will provide power purchase agreements and, providing funding is adequate, supplemental energy payments for those qualifying winners of RPS bid solicitations whose bid price exceeds the applicable market price referent(s). Availability of supplemental energy payments will be a significant factor in the ability to finance a new renewable energy project.

Should the private sector investment community not provide the capital for new generation, it may be necessary for a public entity, such as the CPA to help finance key projects. The CPA may issue bonds for up to $5 billion to help finance the development and installation of renewable energy, efficiency and targeted gas technologies. As reported in the ***Power Authority 2003 Investment Plan,*** the CPA anticipates providing financing for renewable energy resources through the following:

- Finance renewable energy projects that have long-term power purchase agreements with an IOU, obtained through a competitive solicitation,
- Develop, finance and own renewable energy resources at-cost for the benefit of IOU customers, possibly using tax-exempt debt,
- Facilitate the aggregation of small renewable energy resources (under 5 MW) to respond to the competitive solicitations offered by the IOUs, and
- Provide financing or turn-key renewable energy for municipal utilities.

The ***Energy Action Plan*** adopted by the Energy Commission, CPUC, and CPA specifies that "agency actions will attract private investment into California's energy infrastructure to stretch and leverage public funds and consumer dollars." An analysis of whether the RPS is advancing this goal should be conducted at the conclusion of the first solicitation for RPS.

Issues Related to RPS in the Rest of the State

SB 1078 also contains requirements for Publicly Owned Electric Utilities, specifically

"387. (a) Each governing body of a local publicly owned electric utility, as defined in Section 9604, shall be responsible for implementing and enforcing a renewables portfolio standard that recognizes the intent of the Legislature to encourage renewable resources, while taking into consideration the effect of the standard on rates, reliability, and financial resources and the goal of environmental improvement."

Available information indicates that Publicly Owned Electric Utilities are planning the following activities in support of renewable energy development in California.

- Los Angeles Department of Water and Power (LADWP) is currently about 2 percent renewable energy. LADWP recently announced that it will increase its use of renewable energy with such projects as the Pine Trees wind project near Mojave.[102]
- The Sacramento Municipal Utility District (SMUD) hopes to achieve 10 percent renewable energy by 2006 and at 20 percent renewable energy by 2011.[103]
- Roseville Electric has adopted a RPS goal of 20 percent renewable energy. However, unlike the renewable definition used in SB 1078, Roseville counts large hydroelectric generation as part of its renewable portfolio.[104]
- Anaheim Public Utilities recently began two new programs – Green Power for the Grid and Sun Power for the Schools. Both programs allow Anaheim customers to pay a nominal monthly fee to support renewable energy.[105]
- Silicon Valley Power (SVP), serving the City of Santa Clara, already exceeds the amount required by the RPS. For 2002, SVP estimates that 26 percent of its energy is supplied by eligible renewable resources.[106]
- Modesto Irrigation District has committed to develop 30 MW of new renewable energy resources.[107]

Senate Bill 1078 states that Publicly Owned Electric Utilities shall define their own RPS programs consistent with the intent of the Legislature for the statewide RPS goals. A number of Publicly Owned Electric Utilities are planning to define large hydropower as an eligible renewable technology. If large hydroelectric power is used by Publicly Owned Electric Utilities to meet their RPS goals, the amount of additional renewable energy procured beyond existing resources may be smaller, as some of these utilities receive a substantial portion of their electricity from large hydropower. It is important to note that SB 1078 excludes large hydroelectric from the definition of "eligible renewable energy" that applies to Investor Owned Utilities. The use of different definitions of "eligible renewable" for different RPS programs within California may cause confusion to the end user.

Staff conducted a brief survey of Publicly Owned Electric Utilities' activities in support of California's statewide RPS goal. As of September 5, 2003, completed surveys had been received from 14 of the 34 Publicly Owned Electric Utilities surveyed. In addition, two Publicly Owned Electric Utilities did not complete the survey, but responded with general information about their efforts to promote renewable energy.

The survey asked whether the Publicly Owned Electric Utility was taking steps to support California's statewide goal. It also asked respondents to comment on key issues, barriers, or opportunities facing Publicly Owned Electric Utilities with regard to procurement/sale of renewable energy. Finally, respondents were asked what steps, if any, the Legislature should consider to support Publicly Owned Electric Utilities in achieving 20percent renewable electricity by 2017 and by 2010. The results of the survey are summarized below:

- All but one of the respondents indicated that they would do "something" to support a local RPS. Responses ranged from having already met the 20 percent goal (Silicon Valley Power – City of Santa Clara) to the view that the goal is not realistically achievable, but that an effort will be made to comply with the spirit of the legislation (City of Shasta Lake).
- All respondents cited the costs of renewable energy as a key barrier to meeting the statewide RPS goal of 20 percent by 2017.
- Four of the respondents indicated that their RPS will likely be met using large hydro (Alameda, Redding, Roseville and Shasta Lake).
- More than half of the respondents stated that the Legislature should let Publicly Owned Electric Utilities retain local control. Other suggestions included creating a "renewable bank" that the smaller Publicly Owned Electric Utilities could buy from; making Publicly Owned Electric Utilities eligible for the production tax credit; and defining all hydro generation as renewable.
- The most common technologies (other than large hydro) cited as helping meet the RPS are wind, small hydro and PV.
- Results suggest that the two issues with the most negative effect on Publicly Owned Electric Utility RPS efforts to support a local RPS are 1) competition between the IOUs and Publicly Owned Electric Utilities for renewable energy resources and 2) difficulty in financing the construction of new renewable energy.
- Of the issues included in the survey, the issues that have the most positive effect on Publicly Owned Electric Utility RPS activities are the availability of PGC funds for renewable energy; the belief that the transmission needed to bring the renewable energy into their service territories will be built; and the match between operating characteristics of renewable energy and load needs.
- There was a concern among some Publicly Owned Electric Utilities (Glendale, Merced, Modesto, Santa Clara), that increasing support for renewable energy would diminish their ability to fund other public goods programs, specifically efficiency, where they feel money would be better spent.

In addition, the California Municipal Utilities Association has identified a number of RPS-related issues addressing the participation of Publicly Owned Electric Utilities in a statewide renewable development plan. The Energy Commission plans to work with the Publicly Owned Electric Utilities to address these issues in the context of local efforts to implement the statewide RPS goal.[108]

CONCLUSIONS

California can meet its energy needs through a balanced portfolio of supply and demand strategies. The ***Energy Action Plan*** calls for California to prioritize electricity demand and supply strategies as follows: First, work to conserve energy and improve energy efficiency. Second, develop renewable energy and DG. Third, where necessary, meet remaining demand with clean, fossil fuel, central-station generation.[109]

As part of this balanced portfolio approach, California's energy agencies are working towards a greatly augmented role for renewable energy resources in the electricity sector. Toward this end, the state is in the process of laying the groundwork for rapid expansion of renewable energy development through 2017. Transition to this vision of the state's electricity system will face the following challenges.

- Expanding the transmission system to accommodate development of renewable energy resources.
- Improving the economic viability of new renewable electricity generation facilities.
- Addressing the operational compatibility of renewable resources with the existing electricity system.
- Obtaining financing for new, renewable generation.
- Encouraging actions from local Publicly Owned Electric Utilities and other retailers of electricity to procure renewable resources in support of the statewide RPS goal.
- Deciding what role out-of-state generation will play in meeting RPS.

In the next few years, the state needs to take the following steps to realize this vision for renewable energy in California.

- Address implications of the CPUC SB1038 transmission study early in 2004. Transmission costs and constraints in Tehachapi and Salton Sea may delay renewables procurement.
- At the conclusion of the first solicitation for the RPS, the state should re-evaluate the adequacy of public goods funds to maintain the viability of the Renewable Resources Trust Fund to fund supplemental energy payments.
- Support research to increase operational compatibility of various renewable resources and work closely with transmission system operators to identify and overcome system impacts.
- Commercialize results of research and development of renewable energy storage technologies that help renewable energy technologies to operate as dispatchable and/or peaking resources. This will help match renewable energy technologies with operational compatibility and long term commitment needs.
- Monitor RPS implementation for ESP/CCA and implementation of SB 1078 by Publicly Owned Electric Utilities over the next two years in order to identify and address potential barriers as they arise.

CHAPTER 6: RESEARCH, DEVELOPMENT, AND DEMONSTRATION

This chapter presents the role of public interest RD&D in meeting California's goals of providing environmentally sound, safe, reliable, and affordable energy services to its citizens. SB 1389 directs the Energy Commission to develop policy recommendations for public interest energy strategies, and RD&D is an essential component to the development of every one of these strategies. RD&D produce the science and technologies that allow California to adopt aggressive goals in energy efficiency, implement load management, integrate renewables into the power mix, and reduce greenhouse gas emissions. These technologies help to protect the environment while simultaneously stimulating energy-related business activities.

For decades, California has been a leader in energy-related RD&D, and has developed some of the cleanest and most efficient energy technologies in the world. These accomplishments are the result of RD&D efforts conducted by many different institutions, including government, the private sector, and the state's regulated energy utilities. California's regulated gas and electric utilities historically played a major role in funding RD&D that provide both public and private benefits. Beginning in the 1990s, however, the gas production and electricity generation and sales segments of the utility industry became increasingly deregulated. As the ability of utilities to profit from sales of gas and electricity disappeared with deregulation, the source of cash for regulated utility-funded RD&D also disappeared, and funding that could be focused on state and local needs declined rapidly. This decline in utility-funded RD&D led to the creation of a new statewide program called the PIER program in 1998. While energy-related RD&D continues to be carried out by many different institutions, California's PIER program is the largest source of funding for electricity-related "public interest" RD&D in the state.

This chapter begins by providing a definition of public interest research and some historical background about the development of public interest energy research in California. A summary of the primary institutions participating in public interest programs in California follows. The Energy Commission believes that a public interest energy research program is also needed for natural gas supply and use. This need is discussed briefly after the discussion of the PIER program. As a result of the experience gained during its first five years of operation, the Energy Commission has learned some lessons about what will make an RD&D program more successful. One of the lessons learned is that public interest research programs are more likely to have major impacts when they are closely tied to other related public sector programs. Most of the remaining sections discuss the goals and strategies of the PIER program in the context of ten key actions that are being taken by the state to address its major energy issues. Finally, a group of recommendations are offered to augment existing public interest energy programs and to enhance the effectiveness of existing programs.

PUBLIC INTEREST RD&D DEFINED

RD&D can be defined as "the process of advancing science and technology from the initial stages of exploring a concept, through the laboratory and the application testing of components and systems, to the eventual introduction into the market."[110] Most RD&D provides benefits that are both public and private in nature. Since all RD&D can be said to provide some public benefit, it is important to distinguish that which qualifies as "public interest" RD&D[111]. A working definition can be found in the two pieces of legislation that created the PIER program — AB 1890 and SB 90. These bills set forth the fundamental cornerstones of public interest RD&D activities by specifying that PIER should fund only RD&D efforts that

1. Advance science or technology,
2. Are not adequately provided by competitive and regulated markets,
3. Provide in-state benefits of value to California citizens.

In practice, there are no clear lines that mark the boundaries between what constitutes "public interest" RD&D and private or regulated RD&D, nor between what qualifies as "development and demonstration" versus commercialization. As discussed in the ***PIER Five-Year Investment Plan***, boundary decisions are best made on a case-by-case basis by the appropriate governing organization.

INSTITUTIONS INVOLVED WITH PUBLIC INTEREST RD&D

Electricity is an ubiquitous commodity whose generation, distribution, and use affect many aspects of the California economy and environmental quality. Consequently, many state and federal agencies are stakeholders in the outcomes of any research and development program. The PIER program and its principal partners and institutional collaborators are discussed below.

Electricity-Related Public Interest RD&D

The PIER Program

Following the deregulation of California's electric services industry in 1996, the Legislature authorized the Energy Commission to conduct public interest energy research, development, and demonstration. The goal of PIER was to help make California's electricity supply more affordable, diverse, clean and safe. The overall mission is to fill gaps in technology advances once addressed by utilities. PIER takes on critical R&D initiatives that offer near- and long-term benefits to California.

Focusing on Critical Research Areas. The RD&D studies a wide range of energy-related areas including renewable electric generation, buildings energy end-use, industrial, agriculture and water end-use, small fossil-fueled advanced generation, energy systems integration tools and information, and environmental research.

In addition to technology goals, PIER addresses economic goals by focusing on producing nearer term commercial successes. As technologies are successfully deployed in California's electricity markets, the program can further stimulate business activities in a number of ways.

Success Stories. Since PIER's inception in 1998, a total of $254 million has been encumbered to research contracts and program management costs. About half of the encumbered funds had been disbursed through the end of 2002. Most PIER contracts are multi-year contracts, and the remaining half of the encumbered funds will fund RD&D still in progress in these continuing contracts. A review of contracts completed through 2002 revealed a total of 20 commercialized products[112] with projected benefits of $221 to $576 million. Based on the estimated disbursements through 2002, the benefit-to-cost ratio is between 2 and 5 to one.

Sharing Commercial Successes. The value of energy RD&D is lost if the results are not made available to potential users, investors, or marketers. Concurrently, many smaller businesses do not have the resources or expertise to launch their own clean energy technology enterprise or products. The PIER program addresses these technology transfer issues through a variety of innovative means.

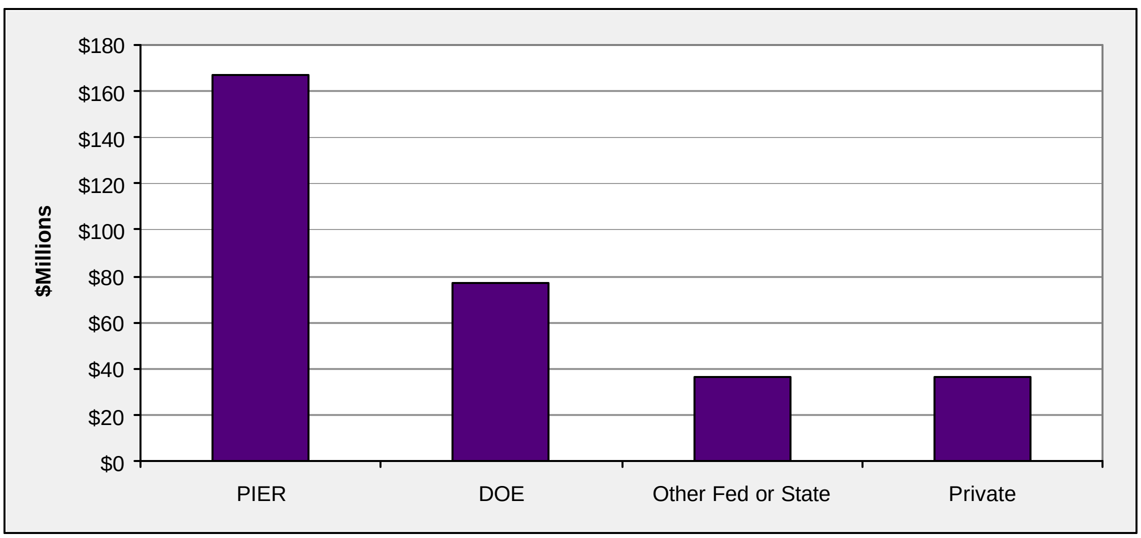
The PIER program is supporting a business incubator pilot program, which assists projects to develop a business plan or marketing strategy that will help them grow a promising business. Currently nine successful candidates are receiving business consulting assistance through the Environmental Business Cluster, an affiliate of the National Alliance of Clean Energy Business Incubators. As the next step toward commercialization, the Energy Commission, along with the National Renewable Energy Laboratory (NREL) and the New York State Energy Research and Development Authority (NYSERDA), supports the Industry Growth Forum, a venture capital forum focused on bringing together California-based clean energy companies with potential investors and providing some PIER-funded projects the chance to present their business plans to venture capitalists and angel investors.

In addition, the PIER program regularly meets with utility program managers to introduce new, energy efficient end-use technologies and coordinate demonstrations or early market introductions through the utilities' Emerging Technology Coordinating Council (ETCC).

One well-known barrier to the acceptance of new technologies by the market is the real or perceived risk to adopters. For example, until the technology has established a track record of success, the adopter faces a risk that the technology will not prove fit for the intended application, that its performance may not be as advertised, or that its costs may be understated. The state could play an important role in reducing the risk of adopting new technologies by developing a technology certification program that verifies the cost and performance claims for new energy technologies.

Maximizing Funding. Publicly-funded RD&D programs must work closely with other state and federal agencies and research institutions to maximize scarce RD&D dollars. Since 2000, PIER has leveraged approximately $150 million of out-of-state collaborative funding to California institutions. Many of PIER's projects have attracted significant financial collaborations with the federal government, other states, and the private sector. This collaborative funding is summarized in **Figure 6-1**. While the outcome of the programs remains to be seen, the effective leveraging of funds certainly enhances the opportunities for success, concurrently boosting California's economy by increasing dollars coming to California-based organizations.

Figure 6-1
R&D Collaborations



In 2003, the Energy Commission will continue to build upon successful collaborations with the DOE, the U.S. Department of Defense., U.S. Department of Commerce, California AQMD, state academic institutions, national laboratories, and other research partners such as the Electric Power Research Institute (EPRI) and the Gas Technology Institute (GTI).

Planning for the Future. The ***PIER Five-Year Investment Plan*** was developed as required by Assembly Bill 995 (Wright) and Senate Bill 1194 (Sher), signed into law in September 2000. The plan addresses the management, research areas, and funding levels for the PIER program from 2002 to 2006 and responds to issues raised by the PIER Independent Review Panel in 2001. The PIER program areas and their funded projects are focused on developing solutions to the problems identified in the plan, which include the following:

- Electricity demand has been rising faster than supply.
- Rising peak demand threatens reliability and power quality.
- Balance is needed between energy needs and environmental protection.
- Market uncertainty and price volatility are impacting energy delivery and use.

Electric Utilities

PIER interacts with many organizations in implementing its RD&D programs. Electric utilities, however, are a particularly important partner for PIER because they are in the business of generating, distributing and selling electricity. Consequently, they are in a position to implement many PIER technologies, and their knowledge and relationships with their customers can also be valuable resources for moving end-use technologies into the market. Utilities have participated actively in the PIER program by serving on project and program advisory committees, by reviewing reports, and by contributing to white papers and planning documents.

Since 1998, when utility RD&D programs not related to the utility business of selling and distributing electricity were transferred to PIER, the utilities have played a lesser role in the conduct of public interest RD&D. Meanwhile, the utility research programs related to the utility business (and not transferred to PIER) have declined substantially. The RD&D focus of the PIER program and the role of the IOUs in that program are being actively debated at this time. The utilities have argued that increased emphasis should be given to Transmission & Distribution (T&D) issues and that programs in those areas should be planned, implemented, and managed by the utilities. Energy Commission staff have suggested that the utilities are free to propose rate-based RD&D programs in T&D to meet their utility-specific needs and that the PIER program should continue to focus on statewide RD&D issues that provide benefits to all electric ratepayers. Although these issues continue to be debated, we see many advantages to maintaining a statewide RD&D program, including the following:

- The costs and risks of research can be shared by aggregating the RD&D programs of individual utilities.
- The free rider problem (i.e., research results are used by entities that do not share in the RD&D costs) associated with research results whose benefits cannot be completely captured by a single funding entity is greatly diminished.
- Externalities (costs or benefits that are not reflected through normal market mechanisms such as the benefits of clean air) can be addressed without competitively penalizing a specific company funding research to address the related issues.
- Higher cost research projects can be funded than could be afforded by a single utility.
- Long-term research that is beyond the usual time horizons for utility planning can be addressed.

There are also clear advantages to a broad involvement of electric and natural gas utilities in PIER programs. The utilities are important stakeholders with crucial roles in the implementation of RD&D programs and deployment of new technologies resulting from these programs. Some of these roles are:

- Primary users of research results,
- Contractor for selected R&D projects,
- Partner for demonstration/deployment activities,
- Source of market intelligence and data for end-user R&D, and
- Advisors for areas of special knowledge or expertise.

One example of a successful partnership is the Energy Commission's public interest R&D in the end-use efficiency area and the investor-owned utilities' implementation of the ETCC. The ETCC was formed under the direction of the CPUC and is comprised of representatives from each of the investor-owned utilities and the Energy Commission. Through the ETCC, the Energy Commission has introduced promising energy efficient technologies to the utilities that have been developed in the public interest through PIER. The utilities, in turn, have helped bridge the gap between R&D and commercialization for these promising technologies through customer demonstrations and performance validations. Through the ETCC, both the utilities and the Energy Commission are successfully leveraging greater value for public interest energy efficiency activities.

Federal Agencies

We have pointed out that PIER relies on collaborations with many federal, state, and local agencies, utilities, and private companies to leverage our budget and to take advantage of RD&D being undertaken by others. However, the DOE stands out in its importance and warrants additional discussion. The DOE is the dominant federal RD&D organization and is responsible for implementing federal energy policies. The DOE energy RD&D budget for fiscal year 2004 is approximately $2.2 billion. This is roughly forty times the funding of the PIER program, making it a very attractive potential source of collaborative funding. In addition, the funding available to the DOE program allows research to be conducted that would be beyond the capabilities of a program of PIER's size. Although the levels of funding for DOE programs at any given time reflect current federal policy priorities, any efforts within California must be cognizant of the DOE budget and programs because of its size, scope, and policy implications. Close collaborations with DOE is an important source of funds that allows PIER to leverage its limited funds. In addition, PIER collaborations frequently influence DOE projects in such a way as to increase the benefits of DOE research for our state while encouraging the expenditures of DOE funding in California-based institutions. This creates a direct economic benefit for California.

Other federal agencies' programs that may complement PIER investments include:

- The new Department of Homeland Security, which will put a considerable amount of funding into critical infrastructure protection; and
- The Department of Commerce National Oceanographic and Atmospheric Administration, which is leading a multi-agency climate change science initiative. This is also valued at over $2 billion.

Other State Agency Programs

A number of states have concluded that successful public interest research programs must track related public sector programs that regulate, subsidize, or otherwise enhance technologies' opportunities for commercial deployment. California's PIER program is designed with this goal in mind. For example, the PIER program is closely linked to the Energy Commission's Title 24 Buildings Standards program. Additionally, PIER works closely with the CPUC and investor-owned utilities to demonstrate new technologies as part of the CPUC ETCC. With the passage of the RPS legislation, PIER is working closely with the Energy Commission's Renewables program as well as the CA ISO to more rapidly deploy renewable energy technologies into the grid.

The PIER program also works closely with the California Air Resources Board (ARB). New small-scale natural gas-fired technologies are being developed to meet ARB's 2007 distributed generation emissions standards. The PIER program incorporates a carbon management technology approach for reducing carbon emissions by enhancing end-use energy efficiency, developing renewable energy technologies, and sequestering CO_2.

PIER is also working with the state's Department of General Services to save operating funds for the state while also providing a convenient test bed for new technologies.

Natural Gas-Related RD&D

Electricity generation in California is heavily dependent on natural gas, with virtually all new capacity in the last decade fueled by gas. The growing use of natural gas for electricity generation has strained the capabilities of a natural gas system designed to meet winter space heating loads in the winter months and to use the summer months to fill local gas storage reservoirs with lower cost gas. An additional demand on natural gas supplies will come from the development of a hydrogen-based energy system, particularly for transportation. Initially, at least, hydrogen is likely to be created primarily by the reforming of natural gas.

These new demands on the gas system come at a time when the major public interest programs at California investor-owned gas utilities and at the national-level Gas Research Institute (GRI) (and its successor, the GTI) are being greatly reduced (See **Figures 6-2** and **6-3**). The California Legislature has authorized the implementation of a public interest program for natural gas that would be parallel in purpose to the PIER program for electricity[113]. The funding level and the selection of an administrator for the new gas RD&D program will be determined by the CPUC in May, 2004. Addressing the funding decline problem of gas public purpose RD&D is long overdue, particularly based on the recommendations included in the ***Working Group Report on Public Interest RD&D Activities*** submitted to the CPUC on September 6, 1996 (see pp 3-17 and 3-18). This report raised "free rider" and cross subsidy issues with establishing a public purpose RD&D program funded only by electricity customers, which was later created by AB1890. The new public interest natural gas research program will be an important resource for California in meeting the new challenges for the gas industry as well as the gas-related needs of the electricity and transportation sectors.

Figure 6-2
California Investor-Owned Utility RD&D Expenditures as a Percent of Operating Revenues

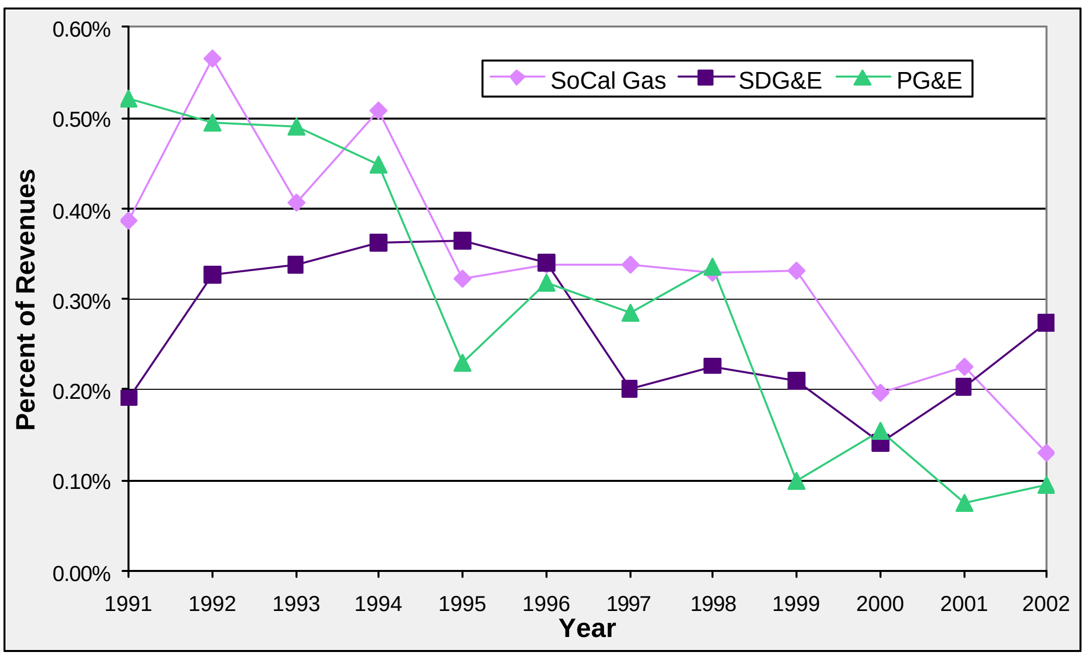
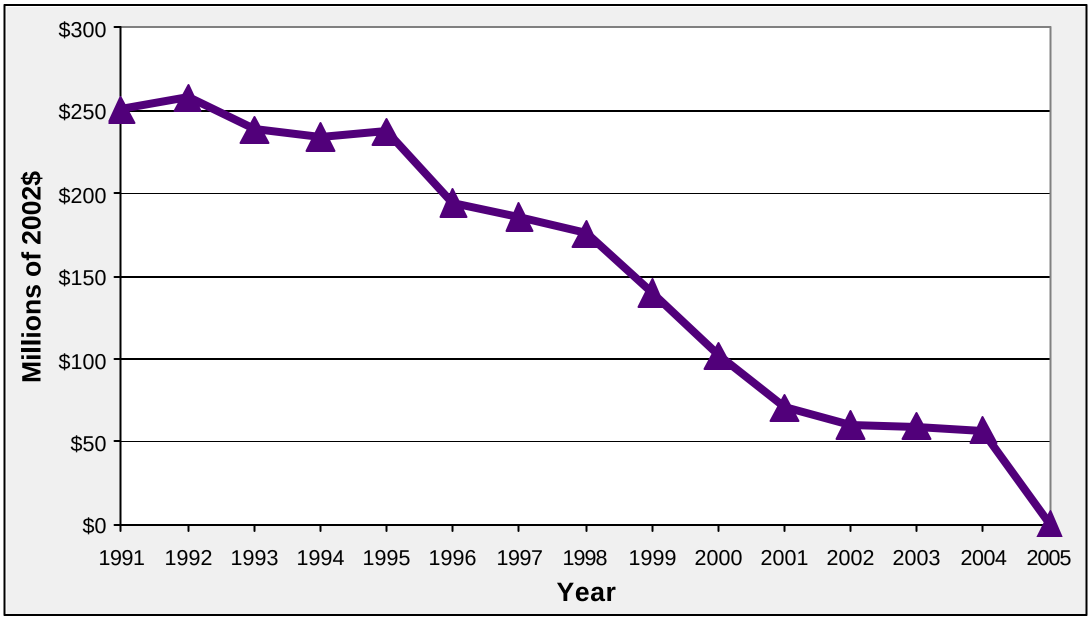


Figure 6-3
RD&D Funding by Year at the Gas Research Institute



Lessons Learned about Managing a Public Interest RD&D Program

In the five years that PIER has been in existence program management experience has revealed several things about *how* to make programs more effective. The lessons learned from these five years of program management experience will be applied to the management of PIER programs in the future.

Lesson 1: Public interest RD&D funding initiatives should be focused in areas where there are other related state programs in action. Related state programs often provide ready markets for RD&D results and offer a valuable source of assistance in commercializing or deploying technologies emerging from the RD&D program. For example, the state public interest deployment programs for renewables and energy efficiency have been valuable in getting PIER renewable technologies and more efficient end-use technologies into the market.

Lesson 2: Administrative flexibility and staff technical expertise are critical in implementing a successful RD&D program. Flexible contracting mechanisms that account for the unique requirements of RD&D contract management and contractor selection are needed to allow for unanticipated changes in the status of projects and to attract the best contractors. Staff technical expertise is critical in identifying research needs, selecting the best contractors, and developing relationships with the best research partners.

Lesson 3: A public interest RD&D portfolio mix should maintain a focus on near-term development and applications. Public interest RD&D programs can help solve pressing short-term problems and can offer significant benefits to the public. Short-term needs are not being met by federal programs, which generally have long time lines for completion and commercialization. PIER constituents and legislative overseers have generally encouraged PIER to increase its focus on near-term problems and market impacts from its RD&D programs.

Lesson 4: Collaborative research should be evaluated by expected ratepayer benefits to California. Collaborating with out-of-state organizations to share research costs is desirable and even more desirable if the research funds projects in California. However, leveraging research funds and bringing outside funds into California are not in themselves sufficient reasons to invest in a research project. Simply leveraging research funds will bring perhaps one dollar of private or other out-of-state funding into California for every dollar of state funding. Analysis shows that research leading to commercially successful products will create at least two to five dollars in public benefits for every dollar of research funding. Thus non-leveraged research projects with commercially successful products will benefit Californians at least as much as leveraged research projects that do not succeed, and will most likely create double the benefits of a leveraged unsuccessful project. Thus, the decision to fund a research project should rely primarily on the expected ratepayer benefits and only secondarily on the amount of collaborative funding.

Lesson 5: All RD&D projects should have exit strategies. For example, projects must be terminated quickly when project goals clearly will not be realized. Technology developers must have an effective management and marketing strategy for technically successful technologies.

Lesson 6: Public interest RD&D can compete with regulated and competitive research programs in creating commercially successful products and creating public benefits. Although there is room for improvement, the PIER program has produced some very real results that will benefit electric ratepayers. PIER recently completed an evaluation of the program's commercial successes through the end of 2002. Twenty commercial products were identified – an impressive number considering that the GTI (formerly the GRI), which is also known for its success in RD&D, produced only 10 commercial products in its first five years. PIER's commercial successes are even more impressive when the funding levels are considered. GRI's total disbursements during its first five years were $621 million in 2002 dollars compared to PIER's disbursements of approximately $125 million.

The benefits to electric ratepayers of the twenty products are summarized in **Table 6-1,** with a more detailed description in Appendix C. The analysis was based on constant 2002 dollars, and benefits in **Table 6-1** are expressed as net present values of savings to product users for projected sales of products through 2006. Benefits accruing from applications of the successful products during the next five years are expected to total between $222 and $579 million, about two to five times PIER cumulative disbursements through the end of 2002.

Research Goals and Strategies for Addressing California Energy Issues

Major California Energy Issues

Many of California's energy issues may be addressed, at least in part by developing short-term solutions that are tied to California regulations, incentives, and subsidies. There has been a recent convergence on six key actions to address energy issues through the Tri-Agency California ***Energy Action Plan***. Four additional actions that will help to address the major energy issues have been identified in the ***IEPR.*** The ten key energy actions, goals associated with those actions, and specific RD&D strategies and activities to achieve the goals are summarized later in this section.

Strategy and implementation must be closely linked to achieve particular goals, so they are discussed together below. Implementation activities must also closely track anticipated trends. In many cases, efforts begun in 2003 will not have an impact in the market until 2008 or beyond because of market trends. However, the results of those efforts are expected to have a considerable impact after 2008 and to contribute to solving long-term energy problems.

Energy Actions and RD&D Responses to the Major Energy Issues

Optimize Energy Conservation and Resource Efficiency. The current Energy Commission research and technology development strategy is closely tied to ***Energy Action Plan*** goals of reducing electricity use per capita and per gross state profit, as well as reducing peak demand. Specific ***Energy Action Plan*** goals amenable in part to RD&D solutions include implementing a voluntary dynamic pricing system to reduce peak demand by as much as 1,500 to 2,000 MW by 2007, improving new and remodeled building efficiency by 5 percent, and improving air conditioner efficiency by 10 percent above federally mandated standards.

Table 6-1
Benefits of PIER RD&D Products Commercialized Through 2002

PRODUCT NAME	RANGE OF BENEFITS ($ Million)
RESIDENTIAL AND COMMERCIAL BUILDINGS END USE ENERGY EFFICIENCY	
Berkeley Lamp	2 - 23
Commercial Kitchen Ventilation	14 - 71
Particulate Emissions Measurement for Unhooded Restaurant Appliances	< 1
Revised Residential Framing Factors—Title 24 Update (2005)	2 - 6
Duct Sealing Requirements for Small Commercial HVAC Systems—Title 24 Update (2005)	40 - 140
Allowable Placement of Roof/Ceiling Insulation in Nonresidential Buildings—Title 24 Update (2005)	67 - 112
Requirements for Skylight Use in Low-Rise Residential and Commercial Buildings—Title 24 Update (2005)	70 - 150
Goettl Comfortquest Gas Heat Pump	< 1
Real-Time Energy Management and Control Systems	Not quantified
ENVIRONMENTALLY PREFERRED ADVANCED GENERATION	
Catalytica Xonon™ Burner	5 - 25
ENERGY SYSTEMS INTEGRATION	
DG Interconnect Hardware	Not quantified
Real-Time Monitoring and Dynamic Rating System For Overhead Transmission Lines	Not quantified
Interconnection Standards for Small Distributed Generators	4 - 16
Improved Substation Seismic Design	1 - 2
Reduced Utility Building Seismic Vulnerability	15 - 20
RENEWABLE ENERGY TECHNOLOGIES	
NO_x Control in Biomass-Fueled Boilers with Natural Gas Cofiring	0.2 - 1
PowerGuard-Solar Electric Systems for Flat Roofs	30 - 80 (Revenues)
ENERGY-RELATED ENVIRONMENTAL RESEARCH	
Low NO_x FIR Burner for Gas Boiler	< 1
INDUSTRIAL, AGRICULTURE, AND WATER END USE ENERGY EFFICIENCY	
Cast Metal Industry Electricity Consumption Study	0.5 - 5
Poultry Rinse Water Recycling	1 - 5
TOTAL	$222 - $579 Million

The RD&D strategy for helping the state to achieve these energy goals includes linking RD&D activities to other state agency programs, such as Titles 20 and 24 and the new CPUC/Energy Commission initiatives for dynamic pricing. For example, the PIER Buildings Program coordinates closely with Title 24 program staff in identifying research needed to inform the building energy standards. The revised 2005 standards incorporate knowledge gained from research, including recent research in the areas of acceptance testing, outdoor lighting, and daylighting. The PIER Buildings Program is coordinating closely now with the Buildings Standards Program to scope out and conduct research needed to inform the next generation of standards in 2008.

In addition, the strategy emphasizes near-term market entry for technically successful technologies. The strategy also targets industrial processes that are significant energy users. Successful technologies will be affordable, beneficial to public health and safety, and easy and convenient to use. To reduce peak demand, PIER strives to develop automatic and effective strategies to make dynamic pricing most effective. Elements of the strategy include the development of new distributed energy systems for better load management and applications of advanced communications, control, and information systems to better implement dynamic pricing and load management programs. To leverage our funding in this area, PIER works closely with DOE and other partners.

The following research activities are being undertaken to implement the above strategies:

- Development of high efficiency AC, ventilation, and air distribution technologies;
- Development of high efficiency lighting technology and natural lighting options;
- Development of advanced building commissioning, energy management, diagnostics, and design tools to ensure the proper operation of building energy systems;
- Improvement of building materials and design to reduce heat transfer through building envelopes, such as cool roof materials and selectively reflective windows;
- Development of high efficiency residential and commercial appliances and controls;
- Development of more efficient water supply and re-use technologies;
- Development of more efficient industrial process technologies;
- Development and deployment of highly efficient and clean distributed on-site generation technologies, encouraging the use of combined heat and power for yet higher efficiency;
- Development and application of sensors, meters, network management tools, and systems integration design to enable enhanced demand response;
- Development and deployment of electricity storage technologies for better load management; and
- Work with state agencies, such as Department of General Services to get new building and appliance technologies installed in state buildings, which will serve as a market catalyst.

Accelerate the States' Goal for Renewable Generation. The accelerated goal for meeting the state's RPS is that 20 percent of electricity distributed by IOUs comes from renewable sources by 2010. Specifically the ***Energy Action Plan*** proposes to add a net average of up to 600 MW of new renewable generation sources annually to the IOU resource portfolio from 2004 through 2010. Statewide, this accelerated goal is roughly equivalent to about 800 MW per year statewide over the 2004 to 2010 period. Success in achieving this goal requires the availability of cost-effective renewable generation technologies and the integration of the new technologies into the existing T&D system, both areas amenable to research solutions.

Current energy technology development activities support the state in meeting its aggressive RPS goals, while remaining consistent with meeting other electricity system needs. The strategy will require the development and rapid deployment of renewable energy technologies, as well as devising technical solutions to overcome significant technical, institutional, and economic barriers. PIER leverages funds in this area by working closely with other entities, such as DOE.

Research activities included within PIER research strategies to achieve the RPS goals include the following:

- Working closely with utilities to determine the best technologies and practices for rapid deployment of renewables;
- Developing technologies and management tools in conjunction with CA ISO that allow for better forecasting and use of intermittent renewable technologies;
- Development of technologies that reduce costs of and emissions from technologies using biomass, digester gases, and landfill gases;
- Development of improved methods and technology for locating, developing, and operating geothermal resources;
- Development of lower cost wind energy technologies for deployment in areas of less-optimal wind resources;
- Development of advanced photovoltaic and solar thermal technologies consistent with the California resource base;
- Development of building integrated photovoltaic systems that take advantage of advances in integration of solar energy systems and building materials for very low energy load housing;
- Continued improvement of strategic value analysis to ensure that resource location, load centers, and transmission congestion issues are properly addressed;
- Performance of environmental assessments for determining potential renewable resource availability and for determining ways to minimize renewable energy impacts;
- Development and deployment of electricity storage technologies to mitigate renewable intermittency problems; and
- RD&D to reduce the environmental impacts of renewables such as wind turbine structures and new T&D lines.

Ensure Reliable, Affordable Electricity Generation. A major goal of the state, as stated in the ***Energy Action Plan***, is to ensure that there is sufficient, reasonably priced generating capacity to meet California energy needs. Specifically, the ***Energy Action Plan*** proposes to add new generation resources to meet anticipated demand growth, modernize old, inefficient and dirty plants and achieve and maintain reserve levels in the 15-18 percent range. This will require an estimated 1,500 to 2,000 MW per year. In addition, the ***Energy Action Plan*** proposes that the state finance a few critical power plants that agencies conclude are necessary and would not otherwise be built. RD&D can provide information and technology choices to help the state achieve both these goals. The majority of technology development activities required for large-scale power plants are being funded by large suppliers such as General Electric or, in the area of coal and nuclear-fuel facilities, by DOE. However, the Energy Commission has supplemental activities where there is a particular benefit to California.

Specific RD&D activities included in the Energy Commission's strategies include the following:

- Development of low-cost approaches to dry cooling technologies;
- Development of a framework for assessing cumulative impacts of hydroelectric facilities leading up to FERC re-licensing proceedings; and
- Studies of electricity markets to better understand reliability and adequacy of supply, retail competition, demand side price response, market design, and market power.

Upgrade and Expand the Electricity Transmission and Distribution Infrastructure. The ***Energy Action Plan*** recognizes that a healthy T&D infrastructure is necessary to achieve other energy goals, specifically ensuring reliable and reasonably priced electricity and natural gas and increasing the electricity supplied by renewable resources. The ***Energy Action Plan*** commits the state to assuring that necessary improvements and expansions to the distribution system and bulk electricity grid are made on a timely basis.

Research can contribute to achieving these goals by identifying T&D system configurations that will take optimal advantage of indigenous renewable resources in order to meet the RPS goal. Research can also identify electricity system impacts due to distributed generation deployment, develop technologies to detect and correct system failures and weaknesses, and identify technical and regulatory options for managing network congestion. California's research funds can also be leveraged by coordinating planning efforts with DOE's new Office of T&D Systems.

Research activities included in the Energy Commission strategies are:

- Development, demonstration, and deployment of technologies, with CA ISO, to better manage system reliability;
- Assessment of interactions occurring with large scale deployment of DER and the grid;
- Deployment of technologies, analytical tools, and public outreach mechanisms to ensure safety and to minimize costs and damage to the electricity infrastructure from natural disasters, such as earthquakes;
- Development of advanced management tools and data systems, in support of CA ISO, for deregulated or changing markets with particular attention to faster, more accurate match of electricity supply and demand;

- Deployment of energy storage technologies to reduce grid power fluctuations and address transmission congestion problems;
- Development of advanced materials, measurement tools, and operating procedures to maximize the capacity of existing transmission lines;
- Development of monitoring and mitigation technologies for minimizing wildlife contact with T&D systems; and
- Use of new models to determine grid locations where distributed generation, DER, and electricity storage systems can provide grid support.

Promote Customer- and Utility- Owned Distributed Generation. According to the ***Energy Action Plan***, "Distributed generation is an important local resource that can enhance reliability and provide high quality power without compromising environmental quality." The plan further proposes to promote small, clean generators near load centers, to determine system benefits and costs of DG, to collaborate with environmental regulators to achieve better integration of energy and air quality policies and regulations affecting distributed generation, and to better understand the issues associated with new technologies and their use. Research can contribute to achieving these goals.

The Energy Commission R&D strategies supporting the above ***Energy Action Plan*** goals focus on the development of cost-effective, environmentally-benign technologies that provide enhanced power quality and reliability as well as collateral benefits, such as heat and transportation fuels. The technology development process includes close interactions with the CPUC, DOE, other states, and state agencies, such as the ARB to ensure that energy and environmental goals are considered. The strategy also includes the development of information characterizing the interactions and impacts of distributed generation and the electricity system.

Specific activities included in the research strategies include:

- Development and deployment of DG technologies that will economically meet 2007 ARB standards;
- Development and deployment of combined heat and power fuel cell systems that offer high efficiency, can support transportation needs, and offer a path to more cost-effective use of hydrogen;
- Establish baseline emissions profiles, evaluate control technology effectiveness, and perform air quality modeling to predict impacts of large scale distributed energy resource deployment;
- Deploy new distributed energy resource systems for peak demand reduction and improved load management;
- Development and deployment of distributed energy resource systems to meet industrial reliability and power quality requirements;
- Assessment of the impacts of large scale deployment of DER on the electricity grid;

- Work with CPUC in the development of standardized interconnection requirements for DER; and
- Development and deployment of DG at industrial sites to reduce electricity purchases, while using waste gases as feedstock.

Ensure the Reliable Supply of Reasonably Priced Natural Gas. The tightness of natural gas supply in California and gas price volatility contributed significantly to the 2000-01 electricity crisis. Several policy actions are identified to better understand and reduce the risks from gas supply uncertainty. Although no specific technology-related goals were enumerated, the Energy Commission believes that research can be of value to the state in achieving the goal of a reliable supply of reasonably priced natural gas.

The Energy Commission R&D natural gas RD&D strategy to date has been limited by the lack of a public interest RD&D program for natural gas. Consequently, our strategic focus is limited almost exclusively to improving efficiency and reducing emissions from smaller, natural gas-fired generators. Implementation includes demonstration and development projects to meet those goals.

The implementation of a public interest RD&D program focused on natural gas is being considered in the CPUC's proceedings for Rulemaking 02-10-001. When this new program is implemented, we expect that it will include such areas as the development of more efficient gas end-use technologies, technologies to reduce leakage from pipelines and distribution systems, reduced environmental impacts from construction and operation of gas distribution systems, safety shutoff systems in the event of an earthquake, and technologies to ensure reasonably priced gas resources. Further, the implementation of a natural gas program will complement existing public interest electricity RD&D due to the nature of the interdependent infrastructures. This will allow the development of joint strategies that benefit both electricity and natural gas ratepayers.

Ensure Critical Infrastructure Protection and Security. Protection of the states critical infrastructure has long been an issue in California because of the risks of system damage from earthquakes. More recently vulnerability of the infrastructure has been of increased interest because of the potential for terrorism targeting key elements of the energy infrastructure. Further, the problem of infrastructure interdependencies has recently been recognized as a major issue. The well-being and costs of our electricity grid is increasingly dependent upon the natural gas infrastructure. Critical infrastructure such as water supply has always been highly dependent upon the electricity grid. Ensuring a reliable supply of electricity requires that the infrastructures for electricity generation, T&D as well as the natural gas distribution system operate without major interruptions. Physical and cyber threats to these infrastructures due to terrorist activities are of growing concern. Planning for possible importing and storage of liquefied natural gas will need to take security concerns into account.

The Energy Commission will support California policies developed by the state's Office of Emergency Services by developing technologies that protect our state's energy infrastructure. In order to maximize the impact of the RD&D, the new technologies will internalize existing and new state regulations. The implementation of the technologies will take advantage of state incentives and subsidies to better protect California's integrated energy infrastructure. Specific research activities will include the development of a "classified" information system of potential targets. Analyses also will be performed to examine and evaluate the "domino effect" on all public infrastructures in case critical portions of California's energy infrastructure become unavailable. Implementation activities are coordinated with federal agency programs, but emphasize programs focused specifically on California.

Support California Global Climate Change Mitigation and Adaptation Activities. The growing concentrations of the so-called greenhouse gases (e.g., CO_2 and methane) in the earth's atmosphere and the effects of these gas concentrations on the earth's climate have been and continue to be hotly debated worldwide. Although there appears to be broad agreement that the increased concentrations of these gases will result in an increase in the earth's average temperature, there are major disagreements about how much the temperature will change, what impact this will have on the climates in various regions of the world, and what should be the worldwide response to these changes. California needs to be prepared for all possible policy responses ranging from aggressive policies to reduce greenhouse gas emissions to policies to accept the outcomes and adapt to them. Research can contribute to California's ability to respond to any policy in the widest possible range. PIER has initiated programs to address climate change issues, including the development of a Climate Change Research Plan, establishment of the Climate Change Center, and publication of a California climate change assessment report.

Electricity generation and use is not as large a contributor to greenhouse gas emissions in California as in the rest of the country. However, any strategy that results in reduced consumption of fossil fuels will also reduce CO_2 emissions. Specifically, PIER strategies to develop technologies to increase energy end-use efficiency and to increase the efficiency of fossil-fueled electricity generation, undertaken to achieve other important energy goals, will also contribute to reducing emissions of greenhouse gases. A third element in PIER's research strategy that allows it to go beyond the limits of increasing efficiency to mitigate CO_2 emissions is the development of technology to facilitate the capture and sequestration of CO_2 produced by fossil-fueled power plants.
The Energy Commission is also preparing for adaptation to climate change by developing roadmaps for addressing approaches to adaptation and by providing more exhaustive approaches to data collection and instrumentation, as well as regional climate model development. These efforts will provide state decision-makers with better information and analysis of trends associated with climate change. Implementation is leading to a better understanding of impacts on ecosystems, agriculture, and forestry, as well as attendant societal costs.

Track Technology Developments Related to Coal and Nuclear Fuel Cycles for Electricity. While not currently being considered, possible limits on inexpensive natural gas, renewable market penetration, and greenhouse gas emissions will require the state to stay abreast of technologies associated with nuclear and coal-fired power plants. We must be cognizant of technology developments in this area in order to address the ***Energy Action Plan*** goal of ensuring reliable and affordable electricity generation.

For the nuclear fuel cycle, waste disposal, non-proliferation, and public health issues prevent its near-term deployment. Furthermore, cost issues will limit the deployment of any nuclear facilities for the foreseeable future. However, new systems are being developed which could be commercialized by 2020 and probably earlier in other locations outside of California. For coal, similar economic issues associated with environmental requirements limit the development of new facilities. However, clean coal initiatives may reduce costs as well as limiting emissions. While California does not need a program in this area at this time, it needs to stay technically informed.

Hydrogen Economy: Leadership Role in Addressing State and Federal Initiatives. Hydrogen has received a considerable amount of attention recently, particularly in light of significant increases in the federal energy research budget. Hydrogen is a very clean burning fuel and it has been touted as an alternative to petroleum for transportation purposes. Hydrogen is essentially a conversion product, much the same as electricity. It must be produced from some other energy resource. It may be produced by hydrolysis of water using electricity, by chemically reforming fossil fuels such as natural gas or coal, or by thermal processes using nuclear energy. If electricity is utilized in producing hydrogen, hydrogen production requires two conversion processes (one fuel to electricity followed by electricity to hydrogen), making it difficult to achieve high overall efficiency. Even if the hydrogen production problem were resolved, the lack of distribution infrastructure, storage technology, and efficient end-use technologies will limit hydrogen in the near-term.

The Energy Commission's strategy for overcoming the high costs of hydrogen fuel is to develop systems and technologies (e.g., fuel cells) that can be integrated to utilize hydrogen both as a transportation fuel and as a fuel for electricity generation. Technologies that serve multiple markets will have greater market potential than a technology serving a single market, resulting in economies of scale for product manufacturers that will drive down the costs. While thermodynamically inefficient, hydrogen can be produced during off-peak periods using low-cost electricity and utilized during peak demand periods. PIER will work with the ARB to continue to support the California Fuel Cell Partnership and California Stationary Fuel Cell Collaborative, as well as other hydrogen-related initiatives. In this manner, it can pool limited resources to pursue demonstration and deployment activities, as well as providing a base for data development and analysis of hydrogen power park initiatives.

Policy Choices for the Future

- The state should therefore continue to encourage the federal government to promote federal R&D programs that complement the California programs and policies. Public interest RD&D programs should continue to collaborate with federal agency energy programs, and opportunities for locating federal energy projects in California should be identified and promoted.

- The CPUC should take the lead in correcting for the funding decline that has occurred during the past decade in natural gas public interest RD&D and should select the most qualified public interest administrator(s) for the state. Natural gas and electricity infrastructures are closely linked, and electricity generation in California is very dependent on natural gas. Complementing existing public interest electricity RD&D with a gas RD&D program would facilitate the implementation of energy strategies that benefit both electricity and natural gas ratepayers. Implementation of such a program is under consideration in the CPUC's proceedings under Rulemaking 02-10-001, and the determination of a funding level for the program and selection of an administrator are expected in May, 2004.
- The state must continue to look at additional ways in which it can encourage commercialization of promising technologies emerging from RD&D. Too often seemingly successful technologies are unable to penetrate the marketplace. Government should become "first buyers" of new technologies that offer benefits to the state. By helping these technology providers, we are also helping to expand the California economy as a whole.
- The state needs to develop and endorse a technology certification program for energy technologies. One already exists for environmental technologies at California Environmental Protection Agency.
- R&D should meet public interest mandates and remain closely linked to related state regulatory incentives and subsidy programs. Legislators should ensure that any new legislation consider and support the linkage between government policy and R&D. The most successful R&D programs are closely tied to policy initiatives.
- The state needs to ensure that all climate change activities within the state are integrated. This will result in the most focused and effective, least cost program.

CHAPTER 7: INTERNATIONAL ENERGY MARKET PROSPECTS

INTRODUCTION

The Energy Commission conducts a program authorized by Public Resources Code Sections 25695-25698 to "assist California-based energy technology firms to export technologies, products and services to international markets." In response to Senate Bill 1389, the Energy Commission evaluates the efforts of California's energy industry to enter international markets, describes Energy Commission activities to promote energy technology exports, identifies export barriers, and recommends new initiatives to address barriers that impede exports. With a modest budget, the program has stimulated over $500 million in export sales since 1988. This represents a 37-to-1 return on government funds invested to promote exports. This program also provides an international business channel for technology advances achieved in California, gains experience in global climate change emission credit trading, and helps maintain a diverse domestic energy industry to service the state's future energy needs.

The Energy Commission provides assistance mostly to small and mid-sized energy companies who need help with overcoming project development barriers. One such barrier is obtaining project financing at competitive terms. Many smaller or less experienced companies lack exposure to financial investors and do not fully understand international project financing techniques. Funding mechanisms are not clearly defined for international energy efficiency, renewable energy and other clean energy projects, which tend to be small and medium in size. Most financing institutions prefer larger projects exceeding $100 million in capital costs to maximize fees and minimize time spent on project reviews. Additionally, California companies have difficulty competing on a "level playing field" with Japanese and European companies heavily supported by their governments. As a result, foreign companies enjoy an advantage over California firms when competing for business in the high growth energy markets of Asia and Latin America.

To address these barriers, the Energy Commission conducts activities to assist California energy companies. For example, the Energy Commission makes awards from its International Energy Fund (IEF), a grant program intended to assist California energy firms with the pre-investment stages of international energy projects. Since 1990, the IEF has funded the initial stages (e.g. pre-feasibility and feasibility studies) of over 90 projects. Success in the initial stages increases an investor's willingness to provide long term project financing. Many of these projects have achieved success, such as the Princeton Development Corporation's wind energy project on the Greek Island of Crete. Completed in 1999, it generated $12 million in revenue for California and created 16.5 MW of wind energy production for Greece. Another California firm, Silk Roads, Ltd. established a US/Thailand joined venture energy services company that negotiated contracts with Thai entities for energy efficiency and cogeneration projects in building and industrial sites. The contracts were valued at U.S. $550,000. These projects, and others, have paved the way for lucrative business deals that produce jobs, revenue, and an increased tax base for California.

California's energy industry has much to offer to the international marketplace. The state's diversity is reflected in its electricity supply mix and energy policies, incentives, and programs that stimulate renewable energy development, energy efficiency measures and other clean energy projects. For 12 distinct energy sector categories, California represents a significant portion (20 percent-85 percent) of all U.S. energy companies. Wind power (80 percent), geothermal (68 percent), and solar energy (85 percent) industries are concentrated in California, while a smaller percent of energy efficiency and conventional energy companies are located there. California's share of the U.S.-based oil and gas industry is estimated at 28 percent (mostly small and mid-size independent companies in Kern County and Long Beach). For each technology sector category, California companies also represent a significant variety of business activities, including equipment manufacturers, project developer/operators, technical, legal and financial consultants, engineers, turnkey operators, and financiers.

The Energy Commission's ***2003 Energy Company Survey***[114] of 152 California energy companies indicates that domestic sales provide the dominant source of income for these firms, their business survival depends on international markets for an average of 24 percent of total sales.

TARGET MARKETS

The Energy Commission actively seeks out new project opportunities for California energy companies by conducting target market studies and surveys to identify the best international prospects for project development. The ***2003 Energy Company Survey*** shows the top market preferences identified by 152 companies in several technology categories (see **Table 7-1**).

Based on surveys, target market analysis and existing commitments, the Energy Commission recommends a focused effort in four countries – Mexico, Thailand, South Korea, and China. These countries are implementing new incentive programs or introducing environmental and energy efficiency standards, but must look outside their borders for suitable technologies and products. Therefore, these countries are strongly encouraging foreign investment (and possibly) foreign ownership. Other countries present opportunities and should be considered for additional analysis or exploration of business prospects.

Mexico is a strong candidate for energy efficiency and cogeneration projects. In both sectors, Mexico ranked as the top market prospect according to energy company preferences (**see Table 7-1**). Mexico has experienced strong industrial growth in the United States-Mexico border area, which has resulted in increasingly severe air pollution.

The United States border states feel the impact of increased emissions from inefficient power plants and boilers, fueling facilities, and traffic congestion.

Table 7-1
Energy Company Market Preferences

Ranking	Biomass	Coal	Cogeneration	Energy Efficiency
1.	Mexico	China	Mexico	Mexico
2.	China	Australia	China	China
3.	Indonesia	Canada	Canada	Canada
	Geothermal	**Hydropower**	**Natural Gas**	**Petroleum**
1.	Philippines	Brazil	Mexico	China
2.	Malaysia	Philippines	Canada	Mexico
3.	Canada	Canada	China	Philippines
	Photovoltaic	**Solar Thermal**	**Wind**	
1.	Mexico	Mexico	Mexico	
2.	China	China	Canada	
3.	Japan	India	Germany	

Source: California Energy Commission's 2003 Energy Company Survey

California's border with Mexico's State of Baja California presents both compelling energy challenges and tremendous business opportunities. Baja California's electricity demand growth rate has averaged 6.5 percent for the last five years and is expected to continue growing at this rate. Population increases and industrialization drive this robust economic and energy trend. Because Baja California is physically separated from the rest of Mexico, it has developed cross border energy relationships with our state. The possible construction of a liquefied natural gas (LNG) terminal near Ensenada, Mexico, will increase its domestic natural gas supplies; excess gas would also be transported to California and ease anticipated shortages in the Western United States.

Baja California's growing electricity need to meet its rapidly expanding economic growth coupled with California's need for additional electricity capacity appears to make the border region a likely area for new power plant development. This will create challenges to avoid increasing existing air quality problems and require new transmission and distribution lines. Baja California also offers unique renewable energy project opportunities to meet growing demand. The Energy Commission's RPS can provide incentives for renewable energy projects constructed in Mexico, which deliver power to California under specific conditions. Though the Energy Commission has not yet provided incentives for Mexican renewable energy projects, Mexico's energy plan anticipates development of several new geothermal, wind power, and solar energy projects.

Of the 3,000 maquiladora manufacturing plants in Mexico along the border, nearly one-third exist in Baja California. With an average electric demand of 1.5 MW per plant and inefficient energy use, these industries are prime candidates for DG and energy efficiency measures.

To help address these issues, California state government participates in the Border Governor's Commission and the Energy Commission co-chairs the Energy Worktable to formulate joint declarations amongst the ten Border States. In addition, the Energy Commission will conduct four energy audit seminars and several energy audits of facilities in the border region during the next year. The goal of audits is to facilitate the development and financing of energy efficiency and industrial cogeneration/central heat and power projects and make them candidates for case studies. The Energy Commission's IEF has also funded eight projects in Mexico and will earmark future IEF funding to stimulate additional energy project funding. California companies provide equipment and develop projects. The Energy Commission will stimulate replications of successful projects by strategically publicizing the "case study" successes to others in the same industry sector and to investors, who might be more interested in a "stream" of projects or a grouping of similar projects suitable for aggregate or syndicate financing.

An Energy Commission target market study evaluated energy intensity use in commercial and industrial sectors worldwide and concluded Thailand was a top market prospect for energy efficiency improvement. Thailand has an overall potential of $163 – 698 million in investments over a five to seven year period. The businesses that show the most potential for energy efficiency project development include hotels, food processing plants, textiles, metal manufacturing, ceramics, and power generation. Recently Thai government agencies and financial institutions embarked on two pilot funding programs to stimulate market demand for energy efficiency investments. In addition, Thailand's Energy Conservation Fund has made $300 million - $600 million available to the energy efficiency and industrial cogeneration sectors for investment purposes. This funding offers additional investment opportunities for California equipment vendors, project developers/operators, engineering and other technical services. To enhance California energy technology exports to Thailand, the Energy Commission would need to conduct a program consisting of energy audits of selected facilities in 20 industrial estates around Bangkok and the industrial areas near Rayong, and trade missions to introduce California companies involved in energy efficiency and cogeneration business.

The Governor's office has committed to mutually beneficial trade activities between South Korea and California, including activities in the energy, biotechnology, fisheries, and agriculture sectors. The South Korean government is restructuring its power industry (as of January 2003), which will provide significant commercial opportunities for private businesses. The privatization of Korea Electric Power Corporation is causing industrialists to examine end use electricity and energy consumption and explore interests in energy efficiency and cogeneration as market rates evolve. During a trade mission to South Korea in June 2002, Energy Commission staff met with several industrialists who feel uncertain about South Korea's ability to keep future electricity prices stable. The Energy Commission proposes to target energy-intensive South Korean industries that might be vulnerable to electricity price increases and recommend demand reduction improvements and possibly onsite power and steam systems that will reduce overall operating costs and enhanced profits. High priority industries include textile mills in Daegu, hotels in Seoul and other major cities, high-rise apartment buildings with central chillers, food processing plants, breweries, microelectronic manufacturers and pulp and paper plants. The Energy Commission's proposal will use a similar strategy as that used in Mexico – stimulate replication sales of individual "case study" projects in each sector by facilitating the development of pioneer projects and publicizing results to others in the same sector. For each project, California firms provide technology or development services.

In the Energy Commission's energy company market preference survey, China ranked high as a target market prospect in eleven of the twelve energy technology categories (the exception was wind). China has a serious air pollution problem, largely the result of its heavy reliance on soft, high-sulfur coal for power generation and industrial uses. However, many of the directors of commercial and industrial facilities in China have limited knowledge of the attributes of energy efficiency technologies. The Energy Commission completed educational seminars targeting 450 directors of commercial and industrial facilities and conducted trade missions to introduce California energy companies. These activities led to business opportunities for California energy companies and increased the use of energy efficient technologies in China.

DOMESTIC TRENDS

The domestic trends identified in the Energy Commission's annual survey of California energy companies indicate that companies will increasingly seek international project opportunities. Since 1980, two significant trends have surfaced. One is that a large number of new companies emerged to supply independent power and build renewable energy projects. The other is that California and the rest of the U.S. electricity market grew at a relatively slow pace. In California, a slight demand increase in the late 1990's created a short phenomenon, but growth rates returned to less than 2 percent/year in 2001. Whereas the domestic market supplied 80 percent of the California energy business revenue in 1988, companies have expressed a greater interest in international business.

An emerging trend identified in the ***2003 Energy Company Survey*** is the inability of energy companies to obtain project financing at competitive terms and the difficulty in obtaining new power contracts in California. Capital investment in new power plants proposed by large independent power producers has waned. Even when a company obtains funding, it must still figure out how to get a power contract approved. According to survey results, regulatory and financial market uncertainties impede the development of new projects.

The impact of all of these trends to the California energy industry is significant. Market uncertainty, lack of new funding and a complicated power sales contract process are trends compelling many California energy companies to seek international markets.

INTERNATIONAL TRENDS

The 2003 survey provided feedback on current international market trends and how they impact business opportunities. The trend that seems to have the most positive impact on business is the development of new technologies, which indicates that research and development programs are impacting the market. Another trend to have a positive impact on international business opportunities is GHG emission policies and global climate change. Specifically, this positive trend is associated with the growth in GHG emissions trading programs. This trend emerged largely from the Kyoto Protocol[115], an international agreement that contains legally-binding GHG emission caps for 39 developed nations listed in the 1997 document. The Protocol also contains provisions for developing countries (such as China and India). They are not subject to emissions targets but can ratify the Protocol and participate in the Protocol's Emissions Trading program.[116]

Emissions trading is one of three "flexibility mechanisms" built in to the Protocol. The Emissions trading mechanism allows national governments and companies to trade emissions credits with the overall aim of reducing GHG emissions.[117] Energy efficiency, renewable energy, cogeneration, methane recovery and fuel conversion projects earn credits that can be banked to meet a country's own goals, or sold to foreign governments and/or private companies to meet their emission reduction goals. Cross border trading, coordinated through the World Bank, the International Finance Corporation, and the Government of the Netherlands has already begun. The economic value of initial trading indicates that methane recovery and some solid waste projects generate credits (revenue) equal to up to 75 percent of the capital cost of the projects. The value of energy efficiency and renewable energy projects range from 5 percent to 20 percent of the projects' capital costs. These GHG emission credits can produce revenue to enhance greater introduction of clean energy projects and meet GHG reduction goals.

The other two flexibility mechanisms are known as Joint Implementation and the Clean Development Mechanism. The Clean Development Mechanism is a market-based system that allows developed nations and/or private companies (donors) to invest in projects in developing countries (hosts).[118] There are two objectives to this mechanism: 1) to lower the overall cost associated with decreasing GHG emissions and, 2) to support sustainable development in developing countries. The investing nation or company will obtain valuable credits [119] that can be applied to emission reduction goals. At the same time, developing countries will be better able to meet their domestic air quality standards while stimulating economic growth. The Joint Implementation mechanism is similar, except that both the donor and host countries must be developed nations.

Already, the World Bank's Prototype Carbon Fund has begun building coalitions with public and private entities to invest in a portfolio of emission reducing projects in developing countries.[120] Several countries and corporations contribute to the Fund. The current funding is at US $180 million. The World Bank intends to invest in 30 to 40 projects, which should be fully approved by mid-2004. An example of one that has been approved is South Africa's Durban Landfill Gas-to-Electricity project, which will use methane from the Mariannhills and Bisasar Road landfills to generate 20 MW (with participation by other municipalities increasing output to 50 MW).

The significance of the GHG trend is that emissions trading will enhance funding opportunities for clean energy projects involving California equipment vendors, project developers/operators, engineering and other technical providers. Emissions trading provides financial incentives for developed nations and private companies to invest money in energy projects, many of which will take place in developing countries. Since developing countries often have to look outside their borders for clean technology options, the competitiveness of California businesses is expected to increase.

RECOMMENDED ACTIONS

1. The Energy Commission should conduct a Mexico Energy Program to fulfill joint declarations developed by the Border Governors' Commission Energy Worktable. The program should address energy and air quality issues on the California-Mexico border and stimulate energy technology exports for California energy companies.
2. The Energy Commission should explore facilitation of greenhouse gas emission credit trading to enhance financing of international energy projects co-funded by the Energy Commission involving California companies. The effort should include activities to gather information on credit values and trading mechanisms that could be duplicated in California.
3. The Energy Commission should develop an international energy project financing network to gather and track information on financing for small and mid-size clean energy projects. Facilitation of information flow should include an annual conference, a searchable website database and matchmaking service linking financial investors with California energy companies.
4. The Energy Commission should conduct concentrated export promotions activities in selected target market countries identified in surveys, market studies and existing commitments.

APPENDIX A: CONSERVATION BEHAVIOR BY RESIDENTIAL CONSUMERS DURING AND AFTER THE 2000-2001 CALIFORNIA ENERGY CRISIS

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UNDERSTANDING AND STUDYING CONSUMER CONSERVATION BEHAVIOR

This report presents results from the Energy Commission study of household conservation response to the complex conditions of summer 2001 in California and the implications of that response for future energy policy. It is part of a larger research study that has also considered the response of commercial/institutional and agricultural consumers to the energy crisis in 2001. This particular report is based primarily upon data obtained from 1666 in-depth telephone interviews conducted with residential households during late September and early October of 2001 and a second survey with a sample of 815 households from the first survey that was conducted from October 2002 to January 2003.

The Problem

Beginning in the summer of 2000, California experienced serious energy supply problems, sharp increases in wholesale (and, in some cases, retail) electricity and natural gas prices, and isolated blackouts. In response to the rapidly worsening electricity situation in California in late 2000, a variety of efforts were undertaken to enhance supply, encourage rapid voluntary reductions in demand, and provide incentives for actions that would result in load reductions. Large-scale conservation marketing campaigns accompanied by financial incentives were directed at residential consumers, who also experienced some price increases, threats of rolling blackouts, and widespread media coverage of the political turmoil and uncertainty surrounding the energy supply system.

The Energy Commission recognized that the crisis presented a unique opportunity to capture information about conservation, including consumers' motivations, decision-making, behavioral responses, efficiency investments, actual energy savings, and persistence of saving. It was recognized that this knowledge could be of considerable value in developing better-informed policies, program designs, and demand forecasts. So the Energy Commission commissioned a detailed evaluation of California consumer response during the summer of 2001 and beyond. The residential sector portion of that research is reported here.

Consumer Behavior in Traditional Energy Policy Analysis

Conventional energy policy wisdom treats consumer demand for household energy as relatively inflexible. Behavior change related to energy use is seen as rare and often resisted, with post-conservation "snap-back" to be expected The implications of this view have included a focus on *price policies* (as motivators) and *hardware programs* (to secure efficiency gains without requiring behavior change). For a variety of reasons, the energy situation in California in 2001 provided a unique research opportunity to critically examine this view.

Before considering our findings, it is useful to briefly recognize the fact that several social science disciplines have literatures that are relevant to the problem of understanding conservation behavior. As a result, the findings reported here also have a significant bearing on social science theory — providing support for some views of consumer action and casting doubt upon others. The literature on household energy use and conservation is voluminous and has been carefully reviewed elsewhere (e.g., see Stern and Aronson 1984, Katzev and Johnson 1987, Lutzenhiser 1983, Shove et al. 1998, Lutzenhiser, Harris and Olsen 2002). Suffice it to say that research shows that energy-related consumer behavior is complex and multi-faceted. Data regarding measurement and verification of energy efficiency and conservation are scarce, making analysis of energy use difficult for both energy users and energy policy analysts. Relatively little of this work has made its way into energy policy discussions, however, and it is useful to consider the evolution of energy efficiency policy in order to understand why.

The Marginal Status of the Consumer in 1980s-1990s Energy Policy

To the degree that energy *conservation* (e.g., using less energy or not using energy or saving energy) has been part of state policy for the past two decades, the concern has focused on justifying energy non-use from a least-cost utility planning framework — and more recently from interest in reducing environmental impacts from increased energy use. The goal has been to acquire predictable levels of conservation by technological means. From the late 1970s through the 1980s, energy conservation measures aimed to improve the energy efficiency of hardware — devices ranging from refrigerators to light bulbs, from motors to building insulation. The "human factor" — e.g., voluntary conservation, frugal use of energy, curtailment of energy usage during periods of peak demand — was seen as too unpredictable and intractable to be a reliable policy target. In addition, the electoral defeat of Jimmy Carter in 1980 was believed to be due in part to his appeals to the American public for frugal energy use during the 1978 energy crisis (Nye 1998).

In the Carter experience, a powerful myth was born for the energy system that went something like this: "...people have come to expect and jealously protect their comforts and pleasures — the tangible markers of modernity and success; they are fickle when their comforts are threatened (see the political demise of previously well-regarded President Carter); therefore, one should never suggest anything that would require inconvenient or uncomfortable changes in energy using behavior; in fact, any change in lifestyle is off the policy table; the "L word" should not be uttered.

Consumer understandings, behaviors, and conservation potentials were not emphasized in energy policy in the 1980s. Rather, policy was dominated by a "resource acquisition" (efficiency as a source of supply) logic. Consumer research was rarely undertaken, and consumer behavior change was not addressed in the marketing of hardware-focused programs and incentives. The consumer was a non-entity in the conservation world, although sometimes invoked in an unflattering way by offhanded reference to "Joe Six-pack," a character interested only in "cold beer and warm showers," who also subverted hardware efficiency after installation and wouldn't purchase energy efficient hardware, even when generously subsidized. Use of this humorous stereotype wasn't necessarily mean-spirited, and we mention it only because it evidenced both limited knowledge and frustration. However, lack of a realistic conception of the consumer was not really a problem, as long as the large and growing energy system could benefit from a continuous accumulation of efficiency gains at the margin.[121]

During the 1990s, a move toward deregulated energy markets led to a retreat of efficiency policy from resource acquisition and a turn toward "market transformation" (MT) approaches, where market actors were encouraged to pursue efficiency for their own self-interested reasons. The shift to an MT-focused energy efficiency policy, particularly in California and the Pacific Northwest caused some renewed interest in behavior. For the most part this involved encouraging suppliers to offer more energy efficient technology and services, and consumers to adopt those technologies and services. The principle of an "exit strategy" by market interveners assumed that there would be long-term changes in markets and presumably in the behavior of market actors. However, an understanding of these relationships was poorly established, and in many ways MT thinking was rooted in the traditional resource acquisition framework. Deregulation and the uncertainty around the potential for deregulation resulted in a significant decline in energy efficiency programs during the late 1990's leading up to the energy crisis.[122]

Enter the Crisis: The Emergence of the Consumer as a Significant Party

When the 2000-2001 energy crisis overtook California, the energy conservation policy framework focused on marginal improvements in hardware efficiency and a hope that competitive energy supply markets might encourage efficiency investment. The concrete policy options available to state leaders in 2000 included accelerating the purchase of hardware (lighting, motors, refrigeration, and cooling systems) and improving large energy users' abilities to track energy use and market prices via interval ("real time") meters and supporting communications hardware/software. Both of these avenues were aggressively pursued by California energy agencies.

However, the magnitude of the crisis required exceptional action. So the California Legislature and executive branch went beyond the conventional policy frame to *appeal directly to energy consumers* via a novel "Flex Your Power" campaign. The campaign used a combination of media messages, appeals from public officials, executive orders to state agencies, news stories, and direct contacts with major corporations, local governments and other large energy users, to ask for voluntary conservation action of *any sort* — action that included *changes in behavior*, such as using less lighting, turning off unused equipment, reducing the use of cooling energy, shifting loads to off-peak times of day, and preparing for rolling blackouts (Bender, et al. 2002).

In this report, we conclude that the events of the 2000-2001 California energy crisis in California provide evidence of the power of behavioral response, and that these findings have significance for the continued evolution of energy policy thinking (policy frames) and policy implementation (programs and initiatives to secure demand-side energy benefits).

The consumer is being asked to assume new risks and take new responsibilities in a changing energy system. As a result, an improved understanding of the interactions between markets, people and technology is required in order to understand how consumer choice and behavior affect energy use and utilization of energy efficient technology — and how these actor/device systems are affected by rates, prices, programs, public appeals, and emergent environmental problems. Our knowledge in all of these areas is limited.

Some work along these lines was being done during the MT period (e.g., see Wilhite et al. 2001, Blumstein et al. 2000, 2001, Lutzenhiser 2002), and that work tended to stress the need to understand energy use, technology choice and economic behavior in *systems terms*. Such a focus on person-technology-institutional systems — or "socio-technical systems" (Hughes 1989) — is not a turn that is unique to energy analysis. It is roughly parallel to the evolution of thinking in the larger environmental policy arena. Mazmanian and Kraft (1999) have noted an evolution of environmental intervention approaches from "command and control," end of the pipe," and "hardware focused" theories and regulations in the 1970s-80s (they call this "Epoch 1"), to "incentive" and "market based" approaches in the 1980s-1990s (Epoch 2), and now to an emerging focus on "sustainable development," "system dynamics," and "community involvement" (Epoch 3). We see thinking about energy, conservation and consumer behavior as evolving along similar lines as well — from a device-centered view to a people-and-devices view.[123]

Of course, all of these forms of thinking continue to be present in the current period, and all contribute to our understandings of phenomena and our ability to influence their dynamics. However, we believe (and we believe that the research reported here helps to demonstrate) that progress in energy efficiency is not well-served when policy development is locked in either Epoch 1 or Epoch 2 thinking. As we move forward, there are clearly important roles for regulations and standards, for well-functioning markets for energy and energy-using goods, and for a variety of both hardware and behaviorally-centered interventions. The trick is getting the mix right. We consider this problem in detail in Section 5 of this report.

Data and Methods

The data used in this analysis were acquired from California consumers, state agencies and major utility companies. Two telephone surveys were conducted by Washington State University on behalf of the Energy Commission, one immediately following the crisis and one a year later. The first telephone survey of 1,666 randomly selected residential electricity consumers was conducted during the months of September and October of 2001. The survey sample was stratified by utility territory, with interviews of between 200 and 400 households conducted in each of the five major California utility service territories (see **Table A-1**). The smaller utilities were over-sampled in order to allow statistical comparisons with the larger utilities in subsequent analysis. The sampling frame was constructed from utility customer accounts and random phone number samples, assuring that all households in the five utility territories were equally likely to be selected.

Table A-1
Completed Telephone Interviews in Each Utility Service Territory

	Year 1		Year 2		Year 2 Response Rate
	Sample	Respondents	Sample	Respondents	
PG&E	3,500	399	355	198	55.8 percent
SDG&E	3,500	411	369	207	56.1 percent
LADWP	3,500	244	208	107	51.4 percent
SMUD	1,166	216	196	101	51.5 percent
SCE	1,200	396	354	202	57.1 percent

Year 2 sample based on Year 1 Respondents who agreed to be resurveyed.
Dual frame samples of 1,000 RDD + 2,500 DL for PG&E, SDGE and LADWP.
For SMUD a dual frame of 566 RDD + 600 DL numbers.
SCE supplied a random sample of 5000 customers, 1200 numbers were called.

For the year 1 survey, 1,666 completed interviews were obtained yielding an overall 24.1 percent response rate and a 40.8 percent rate of cooperation with a plus or minus 2.5 percent margin of error at the 95 percent confidence level. The second survey was conducted from late October 2002 to early January 2003 of 1482 households participating in the first survey who had agreed we could call them back. A total of 815 surveys were completed in this second wave, yielding a response rate of 55 percent.

A detailed literature review and construction of an extensive bank of previously tested survey questions provided a basis for developing the phone survey. Many questions were open-ended. For example, we asked respondents whether they had "made any changes in energy use" and, if so, "what those changes were," rather than eliciting responses from lists of possible conservation actions (and thereby risking a "priming" effect that would result in over-reporting of behaviors). We gathered data on a variety of other topics in the same manner, including open-ended questions about conservation/efficiency actions planned for the future, knowledge of conservation programs, and views of state policies needed to continue the conservation response. The resulting responses from the interviewees' own points of view and in their own words were then categorized and coded for analysis in combination with the pre-coded responses to close-ended questions.

We also collected data on household energy use before, during and after the 2000-2001 crisis from larger random samples of residential utility customers, along with weather data from key weather stations in the various utility territories. Analysis of both survey and large sample consumption data are reported here. Further analysis is ongoing.

In this particular report, we consider how households responded to the 2001 energy crisis, what energy conservation behaviors households were still performing in 2002, what we learned about household energy behavior, and the implications of our findings for energy policy.

HOUSEHOLD RESPONSE TO THE 2001 ENERGY CRISIS

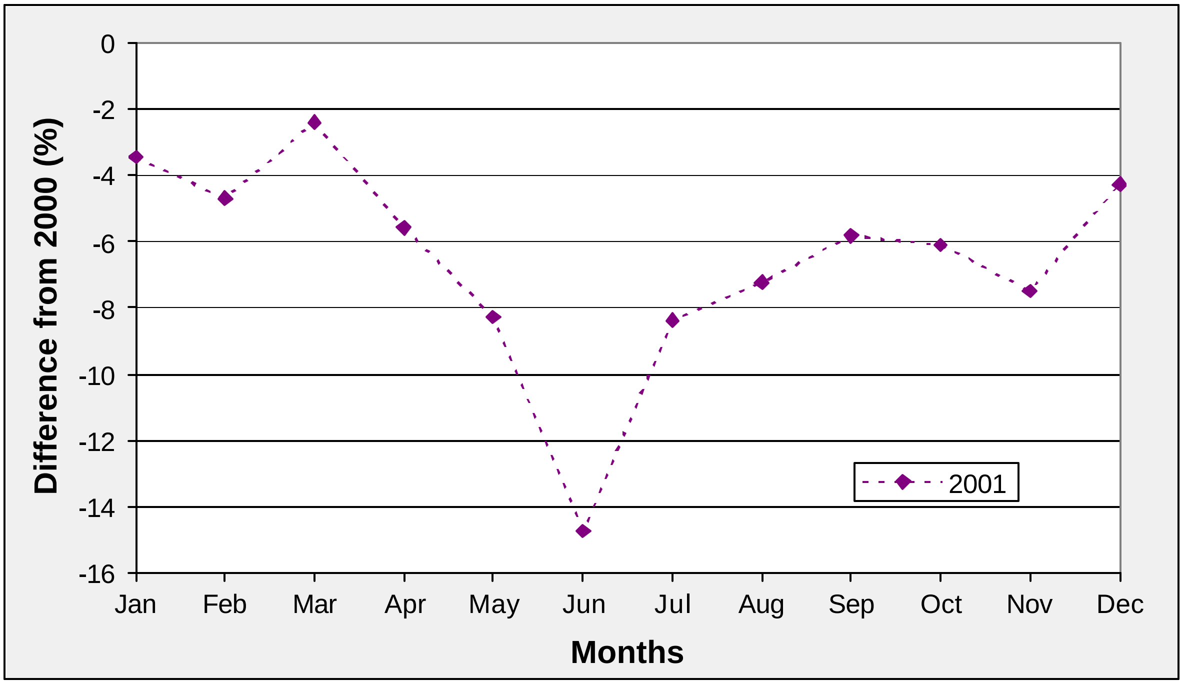
Households responded to the 2000-2001 energy crisis in a variety of significant ways, helping to avert more serious impacts in the summer 2001. In this section we report the key findings from our analysis of households survey responses and system, utility, and household-level electricity consumption data.

FINDING: Unexpected Consumer Ability to Conserve Added Flexibility to the Energy Market. During the summer of 2001 changes in energy use that resulted from Californians' concerns and reactions to the energy crisis were striking. In 2001 Californians reduced electricity usage by almost 7 percent and peak monthly summer demand by 8 to 14 percent, compared to 2000. **Figure A-1** shows the reduction in monthly energy use for 2001 relative to 2000. This is based on recent energy use data from the CA ISO and corrects for the effect of weather and changes in the economy (California Energy Commission 2003a). Widespread energy shortages and rolling blackouts were forecast for summer 2001 in California. At least in part due to conservation response, instead there were no rolling blackouts or stage 3 alerts during summer 2001, and just two stage 1 and two stage 2 alerts. Conservation contributed to this positive outcome. Reductions in electricity demand also helped avoid more serious electric market instability and price volatility.

Energy Savings: Utility Level Analysis

Based on our analysis, changes in consumption for 2001 compared to 2000 were not weather-driven, but reflected changes in behavior. Through cooperative efforts with the 5 major IOUs in California, household consumption data at the utility territory level were made available to our team for aggregate, weather-controlled analyses.

Figure A-1
Monthly Demand Reduction in 2001 Relative to 2000



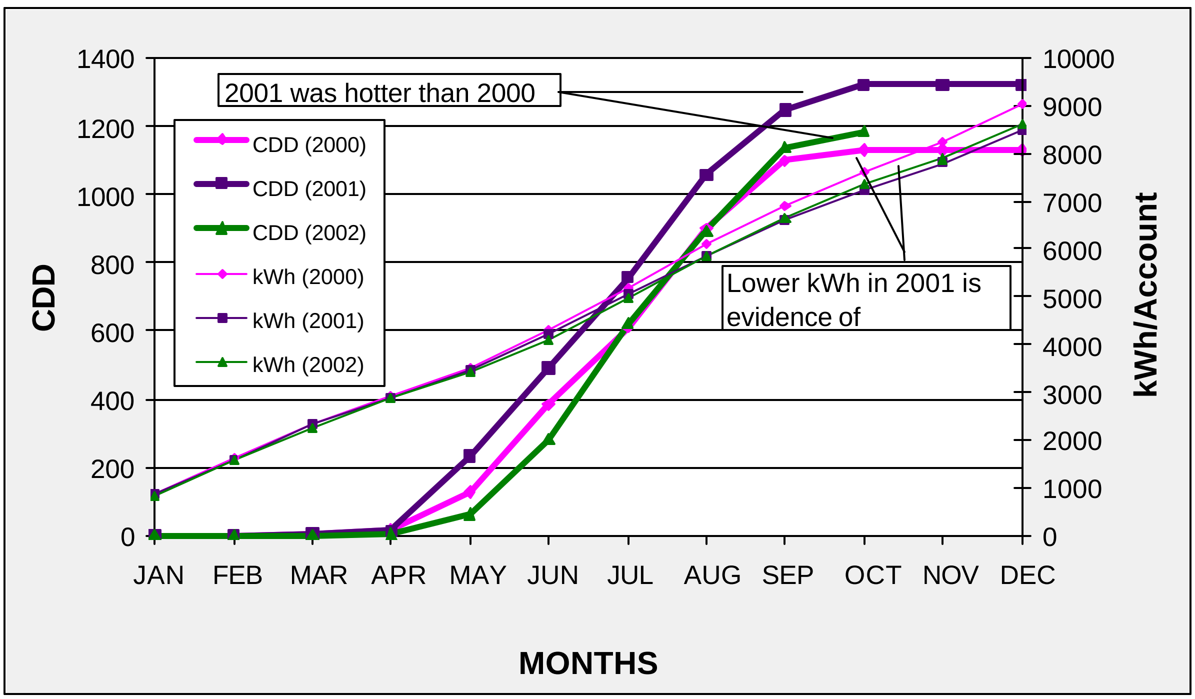
Specifically, our direct evidence on the effect of conservation efforts during the crisis comes from two data sources: the Quarterly Fuels Energy Report (QFER) filed by the utilities with the State of California, and a sample of electricity bills for 5,000 households in each of the utilities studied. The QFER data provide information on electricity use and the numbers of residential accounts serviced by each of the five utilities by month for each of the counties in their service territory. Our analysis combined the data into a utility average per account consumption in each month. We also constructed a monthly cooling degree day (CDD) series for each of the utilities. This was an account weighted average of the CDD in each of the climate zones within the utility areas.[124]

Conservation behavior can be detected by examining the electricity use and the number of CDDs in 2000 and 2001. If it was hotter in 2001 and people used the same amount or less electricity than in 2000, then they must have conserved. Similarly, if they used the same amount of electricity as in 2000 and it was hotter in 2001, then consumers must have on average conserved. This is a simple dominance argument that describes qualitatively if there was conservation, but makes no claims about the magnitude of conservation.

Figure A-2 below shows the cumulative electricity use and CDD for the average household in the SMUD territory. The three lines extending from the lower left to upper right represent the cumulative energy use in each of the years from 2000 to 2002. On this scale the month-to-month variations seem small, but curves clearly become more shallow in the “shoulder months” of April, May, October, and November. For the SMUD territory, it is clear that after May, energy consumption in 2000 was greater than in 2001 or 2002. The later two years are almost indistinguishable. At the same time the two sigmoid shaped curves representing cumulative CDD clearly show that 2001 was much hotter than either 2000 or 2002 (which are nearly indistinguishable from one another). Three conclusions can be drawn from this information:

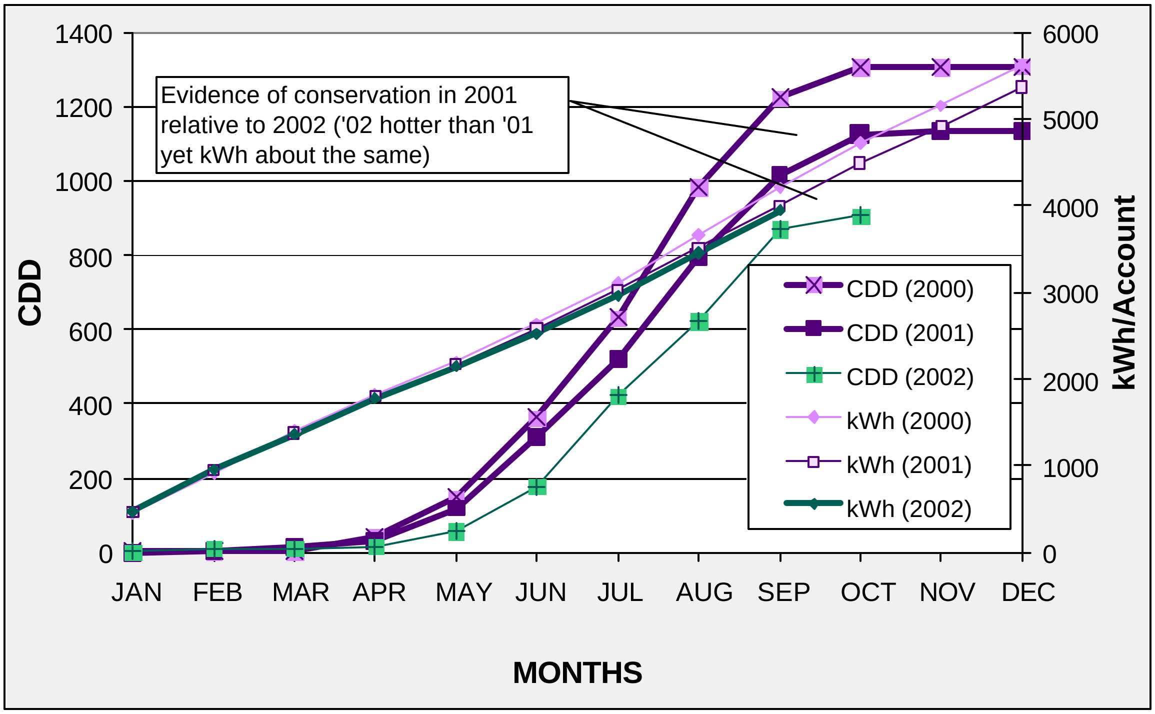
- SMUD consumers conserved in 2001 relative to 2000, because they used *less electricity* when faced with *higher temperatures*.
- They conserved more in 2001 than in 2002, because they used the *same amount* of electricity when faced with *higher temperatures.*
- They conserved in 2002 relative to the pre-crisis year 2000, because they used *less electricity* in 2002 when confronted with *similar weather*.

Figure A-2
SMUD Year-to-Year Comparison, Cumulative Values



In most cases this simple analysis of the QFER data show that Californians conserved electricity during the crisis period relative to the prior year. However, there are some circumstances where this conclusion cannot be drawn. **Figure A-3** below shows the same kind of graph for the Los Angeles Department of Water and Power (LADWP) territory. 2000 was hotter than 2001 and the average consumer in the territory used more electricity. What can be said about LADWP is that electricity use was approximately the same in 2001 and 2002, and that 2001 was clearly hotter than 2002. This means that we have evidence of conservation behavior in 2001, with a decline in conservation effect in the post-crisis year 2002.

Figure A-3
LADWP Year-to-Year Comparisons, Cumulative Values



Similar charts for the remaining service territories are presented in **Figure A-4 through Figure A-6**. Annotations have been added to aid in interpreting the implications for conservation behavior. The conclusion that the reader should reach is that *in all service territories* there is evidence of conservation behavior in 2001 relative to either 2000 or 2002. The data indicate that Californians reacted to the crisis by conserving significant amounts of electricity.

Energy Savings: Household Level Analysis

Our second confirmation of conservation behavior came from an analysis of sample electricity bills provided to us by the five utilities. This analysis considered four of the five utilities. The sample from LADWP proved to be unrepresentative and, therefore, unreliable. Results from that sample are not reported.

Each utility provided a sample of 5,000 bills covering roughly January 1999 to sometime after the summer of 2001. The exact days vary from utility to utility. We were able to assign each bill to a climate zone and then construct the number of cooling and heating degree-days for each of the electricity bills. This resulted in a dataset of about 180,000 observations for each utility.

Figure A-4
PG&E Year-to-Year Comparisons, Cumulative Values

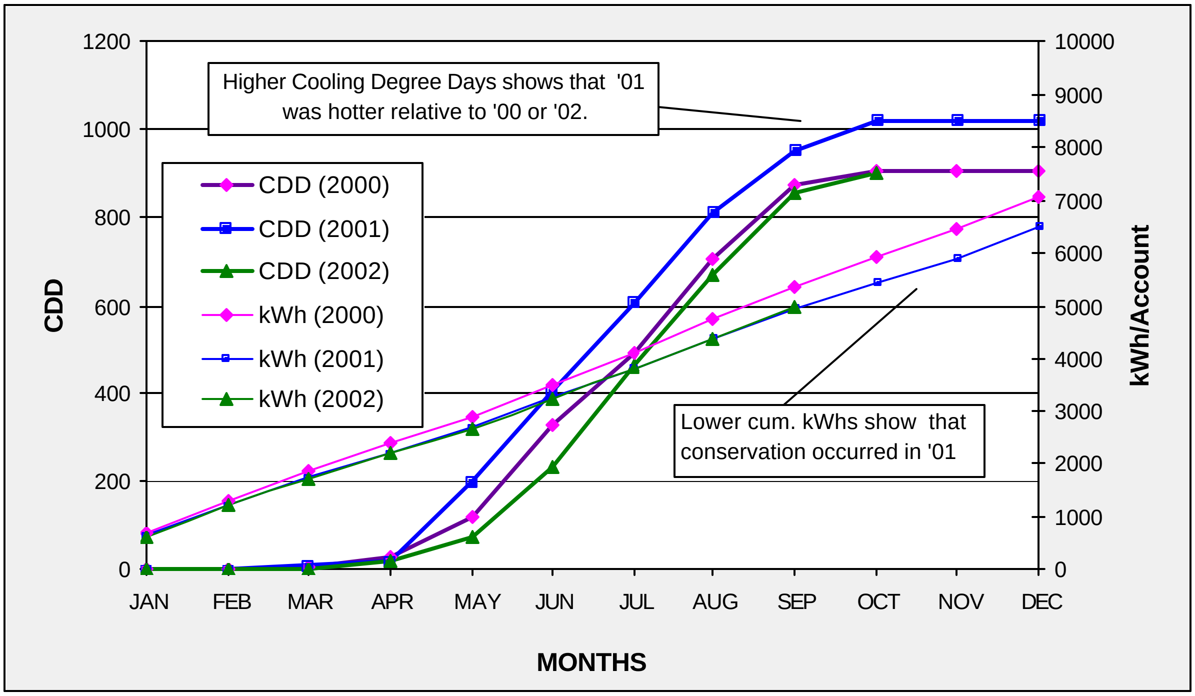


Figure A-5
SCE Year-to-Year Comparisons, Cumulative Values

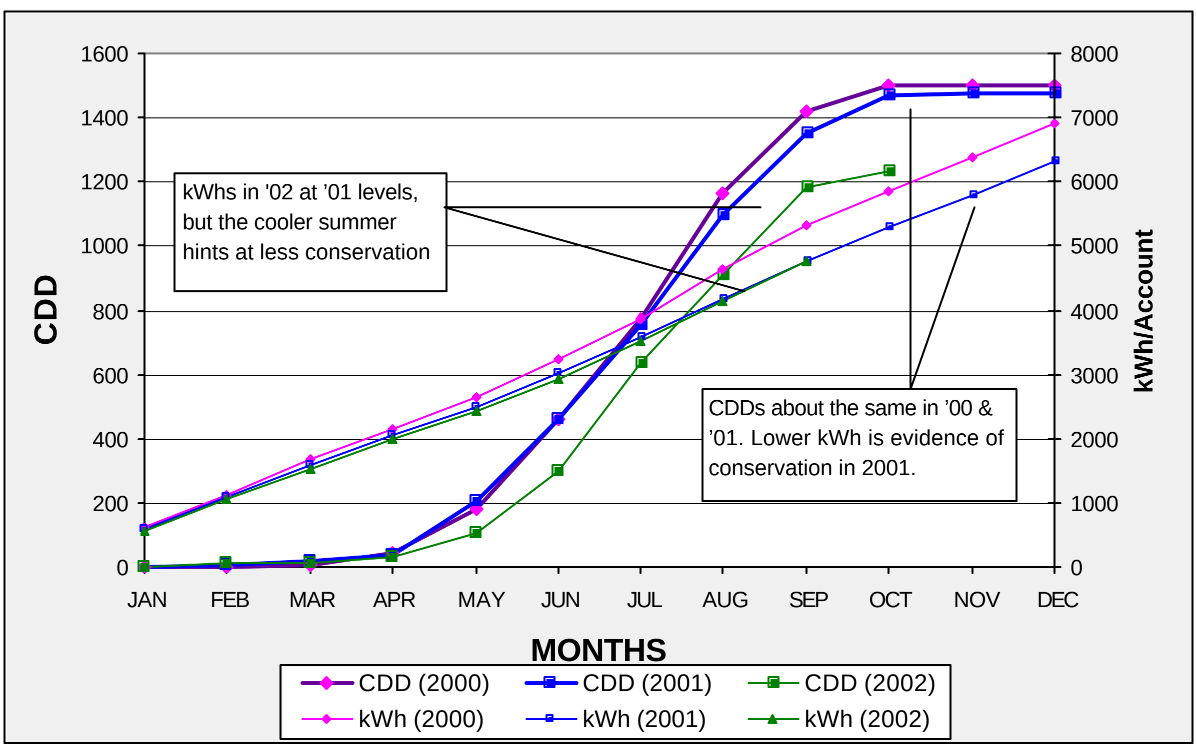
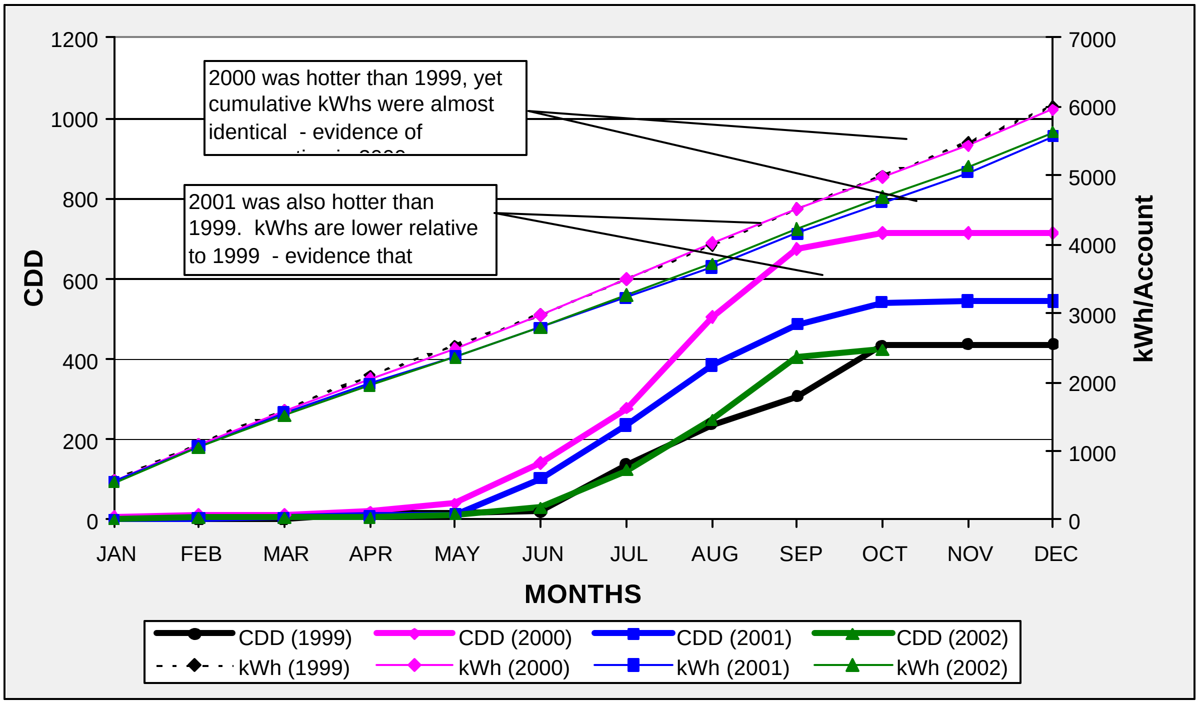


Figure A-6
SDG&E Year-to-Year Comparisons Cumulative Values



The data were used in a relatively simple model of electricity use. Each household has a certain amount of electricity that they use on an average day of the month as a matter of course for lights, plug loads, cooking, etc., regardless of the weather. There is also another component of use that is dependent upon the weather and that is expected to increase with increases in cooling and heating degree-days.

House-to-house differences in size and household habits are important and must also be considered in the analysis. This is accomplished with a linear mixed-effect model that allows each household to have a different base load and reaction to cooling and heating degree-days. The reaction of each household is not explicitly modeled, but is thought of as being random variation around a population average.[125]

The model shows *a smaller reaction to heating and cooling degree-days* in the crisis period than in the earlier period.[126] This indicates that residents conserved energy during the crisis period relative to pre-crisis levels. The change in the reaction to cooling degrees was statistically significant in three of the four service areas. **Table A-2** below shows the reduction in average kWh reaction to a cooling degree-day.

Table A-2
Estimating Conservation Effects at the Household Level
(kWh/day per Cooling Degree Day)

Utility	Change kWh Reaction to CDD	P Value
PG&E	-0.34	<.0001
SCE	-0.22	<.0001
SDG&E	0.02	0.36
SMUD	-1.54	<.0001

This table shows that after 9/1/2000 PG&E customers used .34 kWh less electricity per CDD than they did over the entire sample period. This result is statistically significant, with less than a 1/1000 chance that it would occur by chance if there were no difference. The sole exception to this strong result is in the SDG&E territory, where a small increase is shown, but it is not statistically different from “no change.” The likely reason for this is that San Diego's energy problems started a year earlier, and they simply continued any earlier conservation behavior. We cannot test this hypothesis with our data, since our billing information does not cover that earlier period.

In brief, we have two sources of data and two separate analyses that show that Californians conserved during the crisis period. Using the QFER dataset, our qualitative analysis shows conservation in 2001 relative to either 2000 or 2002 for all five utilities. Using individual customers' bills, we have determined that households moderated their reaction to hot weather by using less electricity, although, to a different degree in each utility territory. A statement that “California households delivered significant conservation benefits during the crisis period” is well supported by these data.

What Did Households Do?

As noted, 1666 households were interviewed in the fall of 2001. Respondents who indicated that their energy-using practices had changed in any way as a result of the Summer 2001 energy situation were asked to describe those changes in their own words. Rather than providing closed-ended choices, which risk over-reporting socially-desirable actions, we opted for an open-ended format. The resulting responses were coded by multiple analysts (with disagreements among them negotiated), and were ultimately categorized into nearly 100 different types of conservation behaviors. For the purposes of this paper, the results are presented using a collapsed coding scheme with 11 categories (**Table A-3**).

Table A-3
Reported Conservation Behaviors

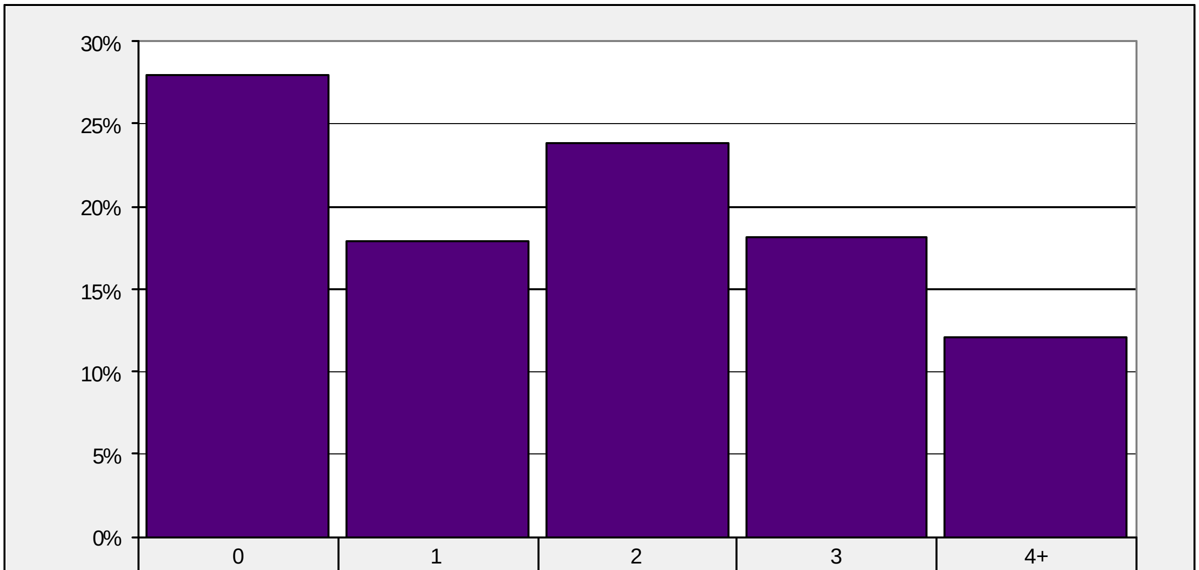
Shell improvement	Hardware related one-time improvements to the house (e.g., windows, insulation, a new piece of fixed equipment such as water heater, AC, furnace, etc.)
Light Bulbs	Hardware related purchase/use of compact fluorescent bulbs or other energy saving/low-wattage bulbs
Appliances	Hardware-related purchased/use of new non-fixed appliances (e.g., refrigerator, washer/dryer, window AC, fans, etc.)
Lights Behaviors	Behaviors related to turning off lights or using fewer lights
Small Equipment Behaviors	Behaviors related to household appliances (e.g., turn off, use less, unplug)
Large Equipment Behaviors	Behaviors related to pools, spas, irrigation motors (e.g., turn off, use less often)
Not using AC Behavior	Behavior related to not using the AC at all
Other Heat/Cool Behaviors	Behaviors related to heating and cooling other than not using the AC at all (e.g., use AC less, use ceiling fans, draw curtains, night venting, thermostat up/down, etc.)
H2O Behaviors	Behaviors related to using less water or using less hot water (e.g., shorter showers, wash in cold/warm water, turn water heater down, etc.)
Peak Behaviors	Behaviors related to using energy during off-peak hours (e.g., washing, cooking, cleaning, etc.)
Vague Behaviors	Behaviors that were stated in general terms (e.g., "be an over-all conserver," "be less comfortable," "use little energy," etc.)

FINDING: Actions Were Widespread Across Households.

More than 75 percent of the households participating in the survey reported taking one or more conservation actions ("conservers").[127] More than half of the households (58.5 percent) took two or more actions, with 2.4 being the mean number of reported. **Figure A-7** shows the distribution of numbers of reported actions taken.[128]

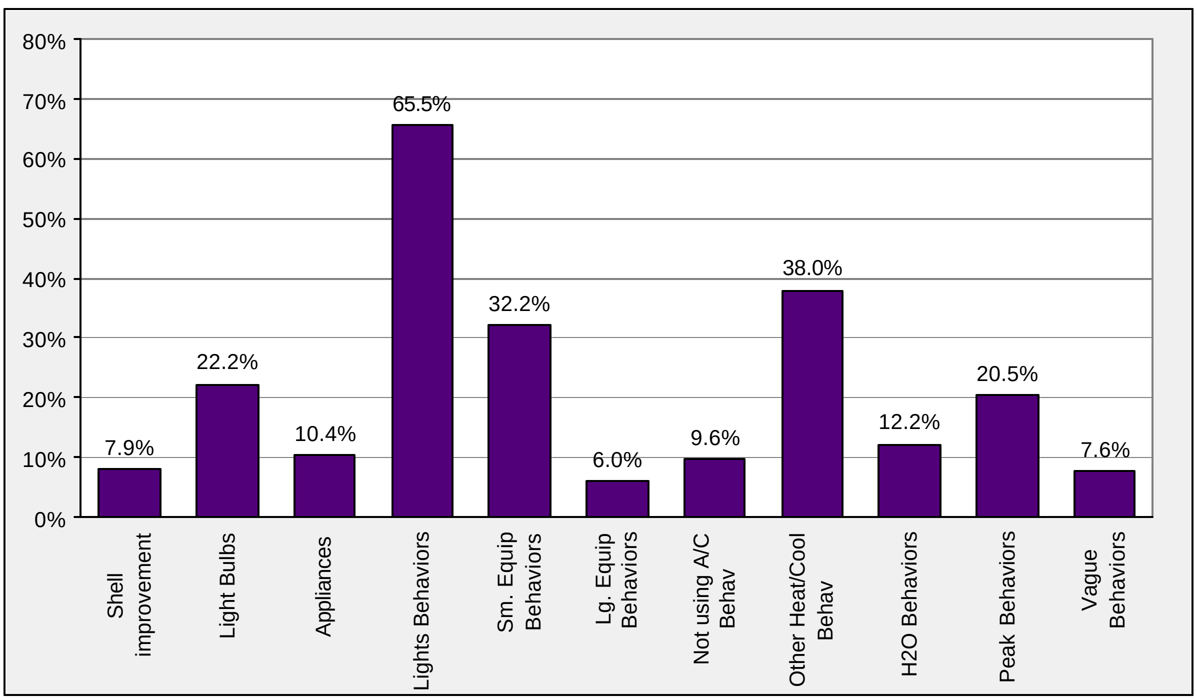
Using less lighting was the most common response (65.5 percent). In all, 9.6 percent of households reported using *no AC at all*, and 48.5 percent took other conservation actions related to cooling or heating. Almost 45 percent (44.7 percent) reported at least 1 change in heating or cooling behavior.[129] Other actions that were reported in the 20 to 30 percent range of households include small equipment behaviors such as turning off equipment when not in use, using compact fluorescent or low energy bulbs, and shifting energy use to off-peak hours. Relatively small proportions reported making major energy efficiency investments in their homes (shell improvements) or investing in energy efficient appliances.

Figure A-7
Numbers of Actions Reported in Year 1



	0	1	2	3	4+
% of HH	28%	18%	24%	18%	12%

Figure A-8
Percent of Households Reporting Different Types of Conservation Behaviors in 2001



FINDING: Changes in Behavior Rather than Hardware Efficiency Improvements Accounted for Most of the 2001 Reduction. As noted, hardware solutions were heavily promoted both during and after the 2001 crisis period, however demand reductions were largely due to changes in behavior. Behavioral actions (e.g., turning off lights, unplugging equipment, using less AC, etc.) accounted for 84 percent of all of the actions reported. This is not surprising, since these can be made on short notice. Among the less frequent actions involving hardware purchases and investments (the first three categories in **Figure A-2**), the installation of compact fluorescent lamps (CFLs) and other low energy bulbs was the most common. Purchasing and installing new light bulbs is by far the easiest hardware action for households to take. Opportunities to make larger energy efficiency investments in the home or purchase energy efficient appliances are quite limited for persons with low and/or fixed incomes, and those living in apartments or rental homes.

The importance of behavior-based demand reductions was confirmed by an analysis conducted by Lawrence Berkeley National Laboratory. This work by Goldman, et al. (2002) estimated that energy efficiency and onsite generation projects that were initiated in 2001 would account for about 1,100 MW of customer load reductions, once all projects are installed. These savings represent about 25-30 percent of the observed load reductions, with the balance being attributable to conservation behavior.

According to their self-reports, households relied primarily on past experience and common sense (likely with some prompting from *Flex Your Power* advertising) to choose the conservation actions they pursued. Many persons, regardless of their present circumstances, may recall frugal use of energy (and other resources) in earlier periods and previous shortages.

FINDING: Clustering and Segmentation of Actions. About a fifth of households (18 percent) reported taking a single conservation action, 24 percent reported doing two different things to conserve energy, and 30 percent reported doing three or more. Because two or more actions were taken by most conserving households, a logical question is whether some of these tended to accompany others. A related question is whether households with certain types of demographic characteristics were inclined to take particular conservation actions.

While there was no evidence that certain types of conservation actions were highly correlated with others, there was a set of core behaviors (turning off lighting, turning off small equipment, and other heating or cooling behaviors) that often appeared in pairs and sometimes altogether. These behaviors represent the most basic type of conservation actions possible. They can be easily adopted and were fairly widespread.

None of the eleven types of conservation action identified above was more likely to be taken *alone* than in combination with other measures. However, for those households taking only one action, some were more likely than others to be reported – major energy efficiency investments (shell improvements), reducing AC, and CFL/low energy bulbs. In fact, one-action households accounted for 20 percent of all major energy efficiency investments to housing and systems. However, major investments were still more likely to be reported in combination with other conservation actions.

Several actions were more likely to occur in households reporting three or more different kinds of conservation efforts. These included: the purchase of energy efficient appliances, low cost energy efficiency improvements, using the TV or equipment less, washing/drying less, and turning equipment off. Almost 90 percent of all high efficiency *appliance purchases* occurred in households taking three or more different sorts of conservation actions.

The *socio-demographic segmentation* of actions we observed in the first year survey often reflected the ability of households to take certain conservation actions. For example, more owners performed all conservations actions than renters in all categories, except for the ones in which renters had a nearly equal capacity to act: shutting off unused lights and shutting off small household equipment. Apartment dwellers, who often have the most constraints on their ability to make conservation investments, were more likely, then, to report purchases of energy efficient small appliances and lights.

Household income was associated to a degree with choice of actions taken. As might be expected, lower income households reported fewer building and appliance changes (reflecting both fewer resources and less home ownership). In terms of "non-hardware" behavioral changes, some income categories were somewhat more likely than others to report taking certain actions. For example, "other heating/cooling" action was more likely to be reported by the $40-75k /year group, "shutting off lights and small appliances" by the $75-100k/year group, and "shutting off large pieces of equipment" (primarily pool pumps and spas) by the $100k+/year group. With the exception of the latter group, the reasons for these differences are not intuitively obvious, and the differences themselves are not large. Overall, behavioral changes seemed to be fairly evenly distributed across income cohorts.

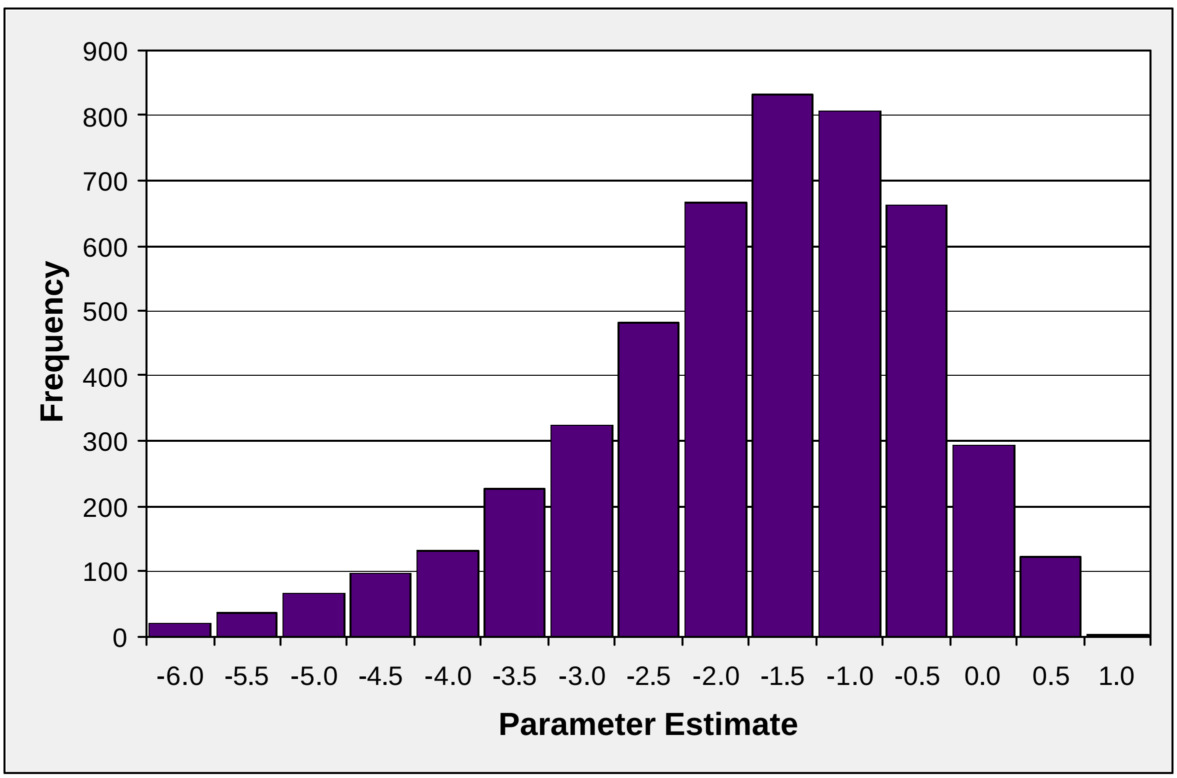
Other segmentation patterns may be the result of messaging via particular advertising channels, although we are not certain of this. For example, it is clear from our data that the Hispanic/Latino audience engaged in peak shifting behavior at a much higher rate than did the non-Hispanic population. More detailed segmentation analysis to attempt to better understand these sorts of patterns will be the subject of subsequent reporting.

FINDING: Actual Reductions in Consumption not evenly Distributed Across the Population. As noted in the utility level analysis discussions above, electricity consumption data from 1999-2001 for 5,000 customers from each IOU (LADWP, PG&E, SCE, SDG&E, and SMUD) were collected and analyzed, along with cooling and heating degree day data (to control for differences the weather). In this analysis, we also found that the distribution of change in customer reactions to cooling degree-days in summer 2001 was highly varied — not everyone reacted to the crisis by saving at similar levels. This suggests that reductions in energy use were somewhat concentrated, with a smaller subset of the population evidencing larger changes than the rest of the population.

While in the system level analysis we aggregated the reaction changes of all of the consumers in each sample, it is also possible to examine each household's change in reaction to hot weather (if any), although with greater uncertainty. There are less data per household, and consequently greater uncertainty about the actual magnitude of any reduction in electricity use per cooling degree-day. In this kind of environment, it is somewhat difficult to detect any "super savers" (e.g., 20 percent + savers) from among the din of average savers. They may not stand above the noise. However, if they can be detected, they will show themselves as a lump (technically, a "skew") to one side of the average of a distribution.

Figure A-9 below shows a histogram of the estimated changes in the reaction to cooling-degree days for our sample of residential customers in the SMUD territory. The highest bar in the histogram, the modal (most frequent) response, is clearly less than zero, indicating that a randomly chosen household is very likely to be consuming less electricity in reaction to cooling-degree days during the crisis year than at other times.

Figure A-9
Distribution of Change in Reaction to Cooling Degree Days



There is also a pronounced tail off to the left indicating that there is a population of "super-savers" influencing the average energy reaction in the SMUD territory. The measure of the extent that these super-savers are detectable is captured in the skew statistic (a measure of deviation from a normal distribution). The histogram shown above has an estimated skew of -1.46, meaning a distribution in which "negative reaction" (conservation) is typical. Several other service territories show similar patterns. **Table A-4** below shows the estimated skew for the four service territories along with confidence intervals for those skew estimates. The gray areas in the table represent a negative skew, which is consistent with the existence of super savers.

Table A-4
Estimates of Skew in Changed Reaction to Cooling Degree Days

	2.50 percent	5.00 percent	10.00 percent	Median	90.00 percent	95.00 percent	97.75 percent
PG&E	-1.03	-0.93	-0.79	-0.32	0.15	0.28	0.42
SCE	-0.14	-0.13	-0.13	-0.10	-0.08	-0.07	-0.07
SDG&E	-0.03	-0.02	-0.01	0.03	0.07	0.08	0.09
SMUD	-1.62	-1.60	-1.56	-1.46	-1.36	-1.33	-1.30

While PG&E, SCE, and SMUD all show some evidence of super-savers, indicated by the negative median skew, only in SCE and SMUD do the super-savers have a strong enough presence to suggest their existence with 97.75 percent confidence. The lack of evidence in the SDG&E territory is likely because of earlier onset of the electricity crisis in that area. While PG&E territory shows some evidence of a skew indicating the actions of super-savers, it is so climatically diverse that under the best of circumstances it would be difficult to detect them by this test. These results suggest that while most of the population showed some savings, there was also a smaller cadre of super-savers that reduced their reaction to hot weather much more than the rest of the population, especially in the SMUD service area.

FINDING: Consumer Willingness to turn off Air Conditioners Likely Made a Large Contribution to Lower Consumption. It is important to note that, with the exception of "turning off lights," cooling-related conservation behaviors were the most frequent reported. These include not using AC at all, plus other (non-AC-related) heating/cooling behaviors, most of which involve using less AC. The actual verbatim responses in this category describe actions such as "draw window shades or curtains during the day," "turn thermostat off when I'm away," "don't use the AC," "use the air conditioner less often," "open windows at night," "open windows in early morning," and "close off part of home to use less cooling."

The results of the survey show that *among households with central AC*, 36 percent reported *using less* or *no AC*. And 29 percent of room AC owners reported using less or no AC. Not only were AC conservation behaviors a commonly reported conservation approach, but they may well deliver the greatest energy and peak demand benefits. Cooling accounts for 35.5 percent of Peak (MW) and 7.4 percent of annual residential consumption (CEC 2003b). Using "back of the envelope" calculations, we would estimate that about a third of the households with AC reduced their AC demand from at least 5 to as much as 100 percent.

The approaches used by households to reduce their AC loads were not recommended by state energy agencies or utility companies in California, even during the height of the 2001 energy crisis. This is because common wisdom in energy program and policy circles holds that residential cooling demand is largely determined by weather and human thermal needs, with AC systems used to offer desired levels of comfort and convenience. In this case, any significant changes in cooling energy use are thought to imply "lifestyle" changes and lower levels of comfort that would be strongly resisted by consumers. Residential cooling is, therefore, rarely an energy efficiency target, (with the exception of efforts to improve Federal AC efficiency standards, and rebate programs to encourage homeowners to purchase newer, more efficient units). During the summer of 2001, the most prevalent cooling conservation message was to set AC thermostats up (e.g., to 78 degrees or higher), rather than to not use AC at all. However, setting thermostats higher was a response reported by only a small fraction of households.[130]

Beyond the Cost Motive

Although consumers were certainly interested in containing costs, a common expectation (particularly by those outside of California) has been that conservation action will not occur without price increases. During the 2001 energy crisis, actual price increases were sporadic, unevenly applied, and often came long after the conservation action was initiated. For some people, behavioral changes were not induced by cost concerns, but rather by civic concerns and altruistic motives. **Figure A-8** above shows that 20 percent of households reported shifting energy use to off peak periods, even though it meant no net savings on their bills.

A majority of households reported a variety of concerns about the energy situation and expressed a willingness to act to reduce their consumption. Almost half of the respondents said they had been thinking "a lot" about the effects of the energy situation on themselves, their families, and friends, while less than 20 percent said that they had been thinking "a little" or "not at all" about the situation. This heightened concern translated into a willingness to conserve energy that was also reported by a number of other surveys conducted at the time (e.g., PPIC 2001; Field Poll 2001a, 2001b; E Source 2002).

Consumers reported a number of reasons why they changed their energy use, ranging from what we might call self-interest (keep my energy bill down) to civic responsibility (doing my part, avoiding blackouts) and altruistic motives (protecting the environment, using energy resources wisely) (**Figure A-10**). Many respondents reported holding more than one of these views. Qualifying for a utility rebate was the least common motivation, and available utility rebates were not relevant to most of the actions consumers took. The majority of those taking no conservation actions at all indicted that this was because they felt that their energy use was already low.

Would Conservation Continue?

Households told us they planned to continue their energy conservation actions. For each reported behavior, the survey respondents were asked how likely they thought they would be to continue it in the future, if the then-current (fall 2001) energy conditions were to continue. For all types of conservation behaviors, 3/4 or more indicated they were very likely to continue the behavior. The actions most likely *not to be continued* were "washing and drying dishes or clothes less” and “using the TV or other equipment less,” although only 10 percent and 8 percent respectively of the people taking these actions gave this response. In addition, almost 60 percent of respondents said taking the conservation action had had no serious effect on their quality of life, and 18 percent even said that they had experienced an improvement in quality of life (**Figure A-11**). These responses suggested that most actions might continue. Actual persistence is explored below using the results of the second survey conducted at the end of 2002.

Figure A-10
Motivations of Households Reporting Various Conservation Behaviors in 2001

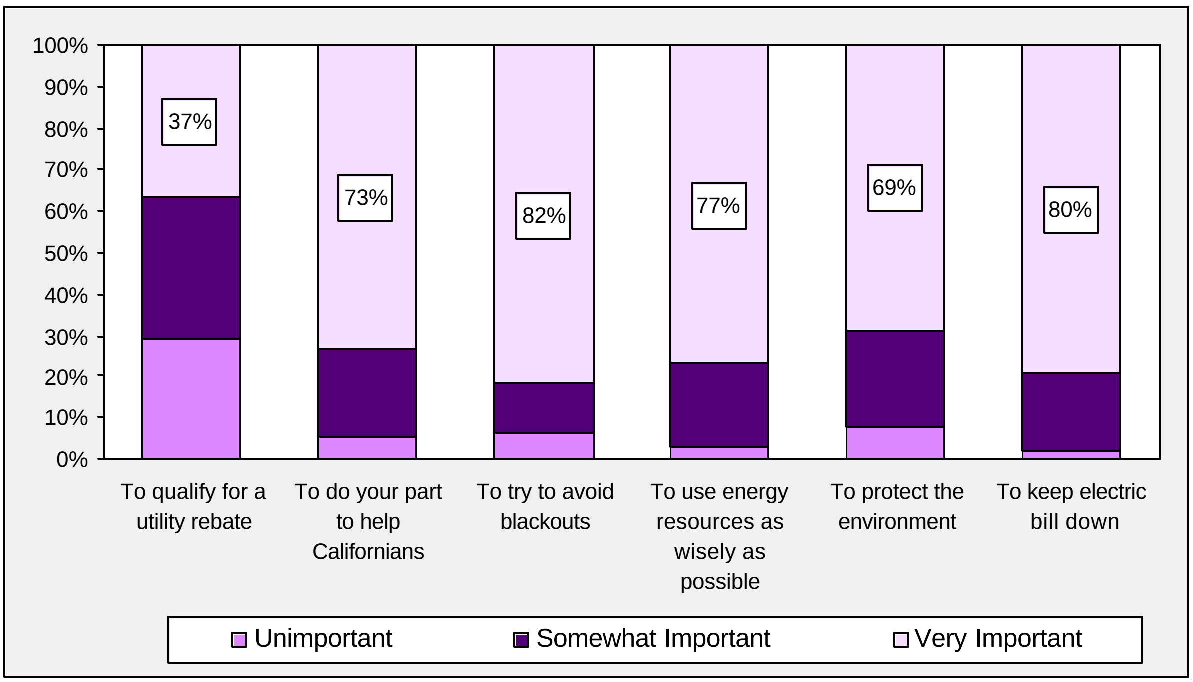
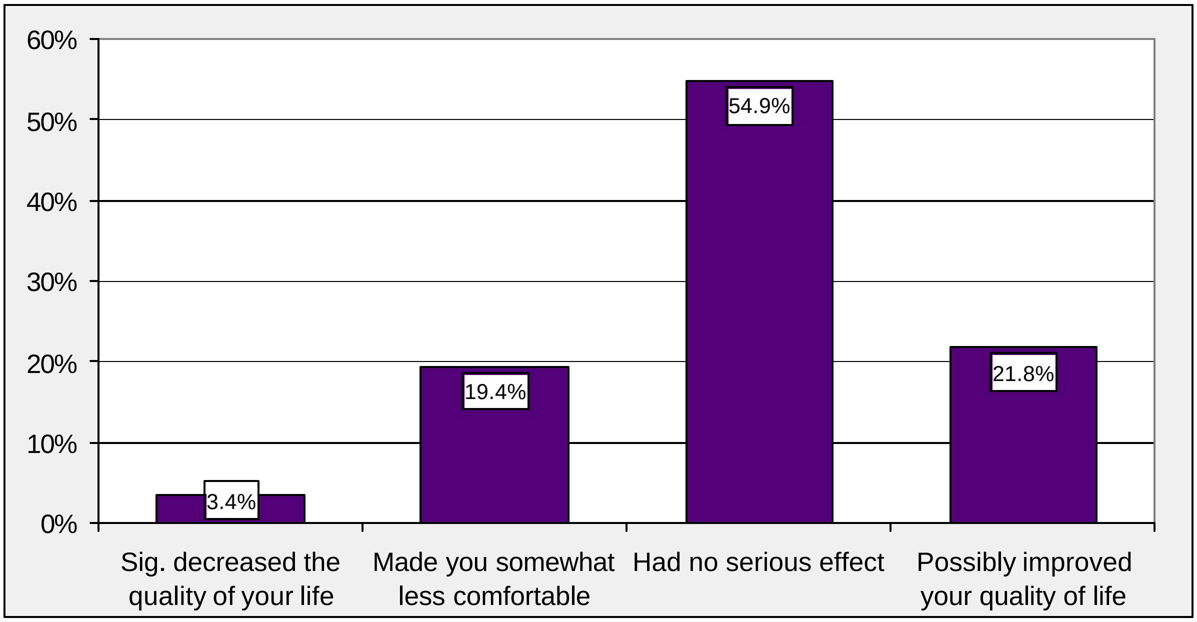


Figure A-11
Conservation and Quality of Life Issues



HOUSEHOLD CONSERVATION BEHAVIOR ONE YEAR AFTER THE ENERGY CRISIS

What were the lasting effects of the 2001 energy crisis on household energy behavior? Conventional wisdom would suggest that continuation of conservation behaviors in 2002 would be heavily influenced by household perceptions of a continuing electricity crisis or significant energy problems, along with price sensitivity to retail electricity rate trends. Given the apparent subsiding of the energy crisis, one might expect a decline in electricity demand reduction. The data support this idea to some extent, but there is still significant evidence of continuing conservation behavior. In this section we report the key findings from our analysis of survey data related to conservation behavior in 2002.

Voluntary Conservation Continued

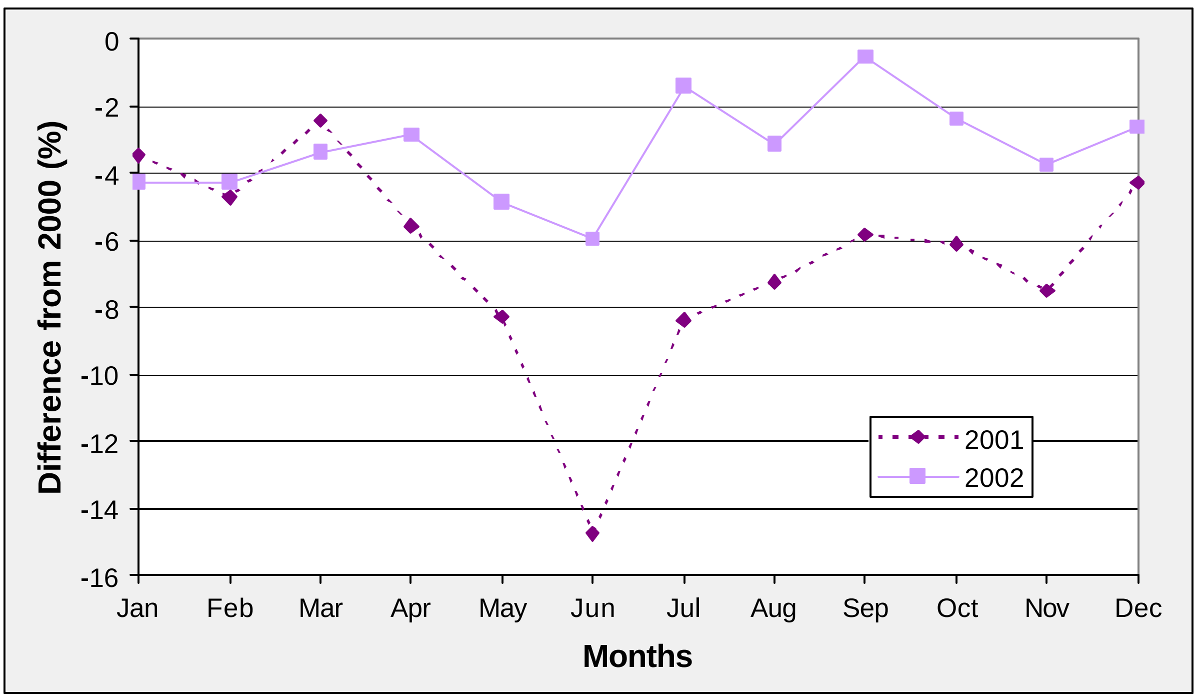
Voluntary conservation continued to produce energy savings, with about one half of the 2001 crisis savings persisting in 2002, controlling for differences in weather between the two years. Recent energy use data from the CA ISO, adjusted for the effect of weather and changes in the economy shows that the reduction in electricity demand in 2002 relative to 2000 is approximately half as much as 2001 (California Energy Commission 2003a) (**Table A-5**). Adjusted annual consumption in 2002 for the CA ISO area[131] was 3.7 percent higher than demand in 2001, *but still 3.2 percent lower than 2000*.

Table A-5
Demand Reductions in 2001 and 2002 relative to 2000

	2000	2001	2002	percent Diff (00-01)	percent Diff (01-02)	percent Diff (00-02)
Actual Metered Load	228,750	216,907	221,105	-5.2	1.9	-3.3
Load Adjusted for Weather	229,213	215,549	221,547	-6.0	2.8	-3.3
Load Adjusted for Growth and Weather	230,911	215,549	223,429	-6.7	3.7	-3.2

Figure A-12 below is a duplicate of **Figure A-1**, but with the addition of demand reductions for 2002 (California Energy Commission 2003a). After April 2002, reductions in demand were smaller than those seen during the 2001 crisis period. However, these data illustrate that overall demand in the CA ISO area has continued to be lower than demand in 2000 – ranging from 6 to less than 1 percent lower.

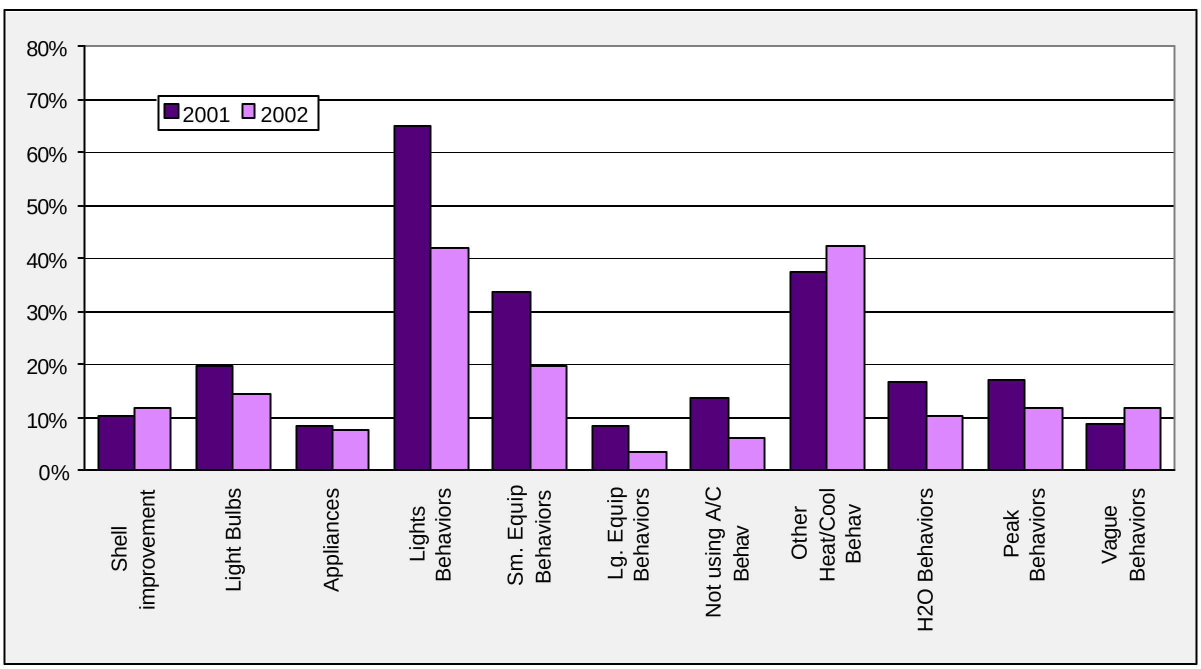
Figure A-12
Monthly Energy Use in 2001 and 2002 Relative to 2000



Continuing Conservation Behavior

A majority of households reported a variety of continuing conservation actions in 2002, ranging from retrofits to building shells, new appliance purchases, turning off lights and appliances, and continued non-use of AC. In our survey in the late fall of 2002 we asked participants about conservation actions that they still might be doing, as well as about their concerns and attitudes a year after the California energy crisis. We found that 90 percent of the households that had reported taking one or more conservation actions in the summer of 2001 were still pursuing at least one conservation action (within the 11 categories reported above). **Figure A-13** compares the percentage of households that took one or more conservation actions in each category in 2001 and 2002, for those households that conserved in 2001. There is a decrease in the number of actions for all but two of the eight behavioral-type actions. Those behaviors declining by at least a third included lighting-related conservation behaviors, small and large equipment-related conservation behaviors, not using AC, and water-related conservation behaviors. There has been an increase in other heating/cooling conservation behaviors other than non-AC use. This is due, in part, to an increase in heating conservation behaviors (which is, in turn, partly due to the survey being conducted later in the year in 2002 than in 2001). For hardware type actions, similar percentages of households pursued site improvement and appliance purchases in 2002, but there was about a 25 percent decline in light bulb conservation actions.

Figure A-13
Percent of Conserving Households Reporting Various Conservation Actions in 2001 & 2002



It is important to note that actions reported by households as continuing in 2002 did not exactly correspond to the actions they reported in 2001. Even though the number of actions reported in 2002 was similar to 2001 for many measures, households sometimes reported a different mix of actions in the two years. For example, for energy conservation related to usage of lights (the most common action) 21 percent of the households reporting this as a continuing action in 2002 did not report it in 2001. Thus, even though 64 percent as many households reported this measure in 2002 as in 2001, 51 percent of the households that reported it in 2001 also reported it in 2002. Since hardware type actions tend to be one-time events, most of the hardware actions reported in 2002 are new actions rather than continuing actions from 2001.

Clustering and Segmentation of Actions

The 2002 data indicate that actions continued to be taken in combination. This suggests a seriousness of intent among conservers, with the choice of *particular* conservation actions depending upon the conditions faced by households and their capacities to act. Some measures can be widely adopted (using less lighting), while the potential may be much more limited for others (e.g., buying an energy-efficient refrigerator).

The patterns of continued conservation behavior were also segmented in 2002, with different consumer groups (e.g., homeowners, renters, hard-to-reach segments) continuing with different sorts of actions. For example, we found that shell improvements are, as expected, made mostly by owners in owner-occupied housing. We found very few shell improvements in renter-occupied housing. What was surprising was that shell improvements were typically made in houses between 1,600 and 2,100 square feet in size. Owners of larger and smaller homes did not make shell improvements at nearly the same rate as those in mid-size homes. As in the case with our first year survey, the effects of household income on choice of conservation action seem to be modest. Again, low-income households (earning less than $20k/year) reported little hardware acquisition or shell improvements, but they did report using less lighting in higher proportion than other income groups.

We also found that CFLs were more often purchased by households with two adults. The number of children or income seemed to have no effect on the rate of CFL purchases. These same kinds of households were more also more likely to turn off the large equipment in a house, or engage in peak shifting behavior, but were no different than single adult households in the rate at which they shut off unused lights or purchased energy efficient appliances. This is typical of the segmentation patterns we have seen in these data. It is not a specific socio-demographic group responsible for particular conservation behaviors. Rather, they are distributed fairly evenly across the population.

Actions Abandoned and New Actions Adopted

While some consumers reported a decline in their conservation actions, others reported new efficiency choices, and the adoption of new conservation behaviors in 2002. We specifically asked the households that reported conservation actions in 2001 if there were things that they were *no longer doing.* About 8 percent of the conserving households identified actions they were no longer taking. Discontinued actions included (percentages are for the subset of "discontinuers"):

- Using AC less or thermostat set down (44 percent)
- Less dish/clothes washing & line drying (19 percent)
- Equipment turned back on and runs longer (18 percent)
- Not cutting back on heating (11 percent)
- No longer turning lights off (9 percent).

Respondents often gave multiple reasons for taking fewer conservation actions in 2002. It is interesting to note the importance of *habit* and the relative unimportance of *inconvenience* in the reasons given. The most common reasons for discontinuing actions were:

- "Just easy to slip back into old ways" (46 percent)
- "No need after summer" (34 percent)
- "With crisis gone, no more need" (12 percent)
- "Security reasons" (7 percent)
- "Too difficult or inconvenient" (2 percent).

Some households reporting conservation measures in 2001 also reported taking new conservation actions in 2002. Twenty three percent of those households, in fact, added conservation behaviors that included (as percentage of those adding actions):

- Other heating or cooling behaviors (23 percent)
- Lights-specific behaviors (23 percent)
- Light bulbs: hardware (19 percent)
- Small equipment behaviors (19 percent)
- One-time shell improvements (15 percent).

Nineteen percent of the households responding to the 2002 survey had reported not taking any conservation actions in response to the 2001 crisis. As noted, the majority of these indicated the reason was their already-low energy use. In the 2002 survey, however, when these households were asked if they had taken any new actions to conserve energy, about a third indicated that they had. Primary actions included buying CFLs and other low-energy bulbs and using less lighting.

A Closer Look at Hardware: Appliances and the Potential for Further Energy-Efficiency Purchases

In both years of the survey, respondents were asked to tell us about the appliances in their homes. In the first year, we asked for a list of major appliances considered old enough that they might be candidates for replacement. Forty percent of the sample (478 households) reported having at least one appliance that was a candidate for replacement, and many listed more than one. The results, displayed in **Table A-6**, range from 32 percent of households reporting older refrigerators to 8 percent reporting older room/window AC units or dishwashers.

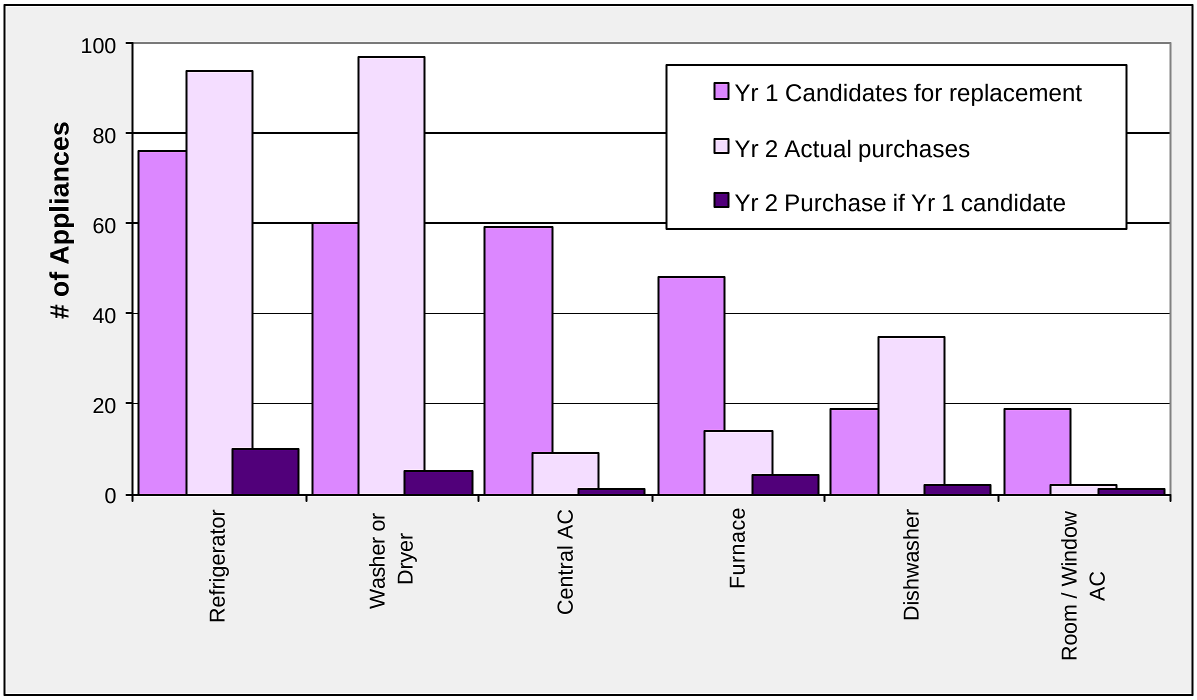
Table A-6
Percentage Distribution of Households Reporting Appliances as Candidates for Replacement

Appliance Type	Households
Refrigerator	32 %
Central AC	28 %
Furnace	17 %
Clothes Dryer	15 %
Clothes washer	10 %
Room/Window AC	8 %
Dishwasher	8 %

The following year, we asked about major appliance purchases in 2001 and 2002. We found that owning appliances considered old enough to replace is not highly correlated with actual replacement. **Figure A-14** shows a comparison of (1) the sorts of units that are candidates for replacement, (2) the sorts of units that were actually purchased, and (3) the proportion of those with old appliances (candidates in year 1) who replaced them. Refrigerators and washers and dryers are both good candidates and were purchased by many participants. However those who made the purchases were unlikely to be those who reported the candidates for replacement. These may be more likely to be purchased during a move or a remodel or as part of a stylistic (as opposed to a functional) upgrade. While central AC and furnaces are surprisingly good candidates (with significant energy savings potentials), they were infrequently replaced. Replacement most likely happens when the equipment fails or during a major remodel. Finally, dishwashers are similar to refrigerators, but at lower levels of replacement, and room/window AC looks like central AC, but also at lower replacement levels.

As in the analyses of conservation action segmentation reported above, examination of patterns of income and home ownership in terms of both replacement candidacy and purchase likelihood reveals some not-surprising patterns — e.g., with older equipment often found in lower-income and renter households where it is only infrequently replaced. The point is that an array of behavioral factors is at work in the distribution of technologies across the population, and in the processes of choice and purchase of new appliances and fixed-in-place building systems.

Figure A-14
Replacement Candidate Appliances and Actual Purchase Patterns



Probability that Households Under-Reported Behaviors

Our analysis of the continuing and discontinued actions reported by year-one respondents in the year-two survey would not be complete without discussing some important reporting anomalies. In a detailed comparison of year-one and year-two actions at the household level, we found that in some cases, respondents reported continuing or discontinuing an action that was not mentioned the previous year. In the year-two survey, we did not provide the respondents with a list of the actions they reported the previous year. This was a methodological choice made to avoid leading or prompting respondents to reply with what might be considered the socially desirable response — that is, simply confirming that they have continued all of their conservations actions. It also allowed us to gain some insight and to compensate for an often-stated weakness of open response surveys — the tendency to understate action.

Because the respondents are not prompted for our predefined categories, they must formulate and recall their own actions. They are likely to forget to mention some actions that they thought had been important, or other conservations actions that they might think are too obvious to mention.

Estimates of conservation behaviors, rather than the behaviors that they report, can be constructed by combining the reported behaviors in the two survey years. Observing an individual who does not mention “turning off lights” as a conservation behavior in the first year, but then reports that they are continuing that behavior the second year, contributes to an estimate of how frequently the respondents may be under-reporting the actions they are performing. **Table A-7** displays both the adjusted percentage of respondents in the sample that reported a conservation action[132] and the lower bound on our belief about what fraction of the California population may actually be performing the action.[133]

Table A-7
Reported Actions and Probable Performance

	Sample Adjusted Reports	Population Prediction	Sample Adjusted Reports	Population Prediction
	Year 1		**Year 2**	
	Reported Action	Performing Action	Reported Action	Performing Action
Shell improvement	8.2 percent	15.3 percent	13.2 percent	17.8 percent
Light Bulbs	16.1 percent	20.5 percent	15.4 percent	14.1 percent
Appliances	6.9 percent	16.6 percent	9.0 percent	18.0 percent
Lights Behaviors	52.5 percent	86.0 percent	42.5 percent	89.7 percent
Sm. Equip Behaviors	27.1 percent	35.9 percent	22.2 percent	25.2 percent
Lg. Equip Behaviors	6.9 percent	15.6 percent	4.3 percent	15.9 percent
Not using A/C Behavior	11.0 percent	15.2 percent	15.1 percent	18.8 percent
Other Heat/Cool Behaviors	30.2 percent	60.2 percent	40.9 percent	73.9 percent
H2O Behaviors	13.6 percent	18.6 percent	9.8 percent	9.0 percent
Peak Behaviors	13.6 percent	21.3 percent	10.5 percent	10.9 percent
Vague Behaviors	7.1 percent	60.0 percent	11.2 percent	85.9 percent

In some instances the lower bound on our beliefs about actions are much higher than the fraction of the sample reporting actions. This is actually very understandable. Consider the simple behavior of shutting off the lights. In both years a relatively high fraction of the population, 52.5 percent and 42.5 percent, reported that they shut off the lights when they were not being used. We believe that this faction is actually higher because many of our second year respondents reported that they were still shutting off the lights, when they did not report shutting off the lights in the first year. In fact, about a quarter of all those household that we report as shutting off lights told us about it in the second year as continuing behavior that they did not report the first year of the survey. This provides evidence of the chances that they would forget to tell us. Roughly speaking, there is only a 75 percent chance that they mention the lights when they do shut them off when not in use.[134]

Closed response surveys have the opposite problem in that they consistently overstate the incidence of conservation actions. For example, the Evans/McDonough survey conducted in February 2001 (E Source 2002), found that 42 percent of the population virtually always "Turn[s] off and unplug[s] appliances, including your television, VCR, lamps or computer, when they are not in use." It is unlikely that such a large fraction of the population is actually performing this extreme action, and, in fact, in our open-response survey less than 5 percent of the population mentioned unplugging appliances, televisions, VCRs, lamps or computers when not in use.[135]

In our survey, we would estimate that the likelihood of any given household performing most behaviors exceeds the rates at which that behavior is reported. We are not certain by how much, and the estimates in **Table A-7**, while carefully calculated using consumers' own self-reports in 2001 and again in 2002, cannot be presented with great confidence. However, we *are* fairly confident, on these same grounds, that self-reports of habit-grounded conservation may well under-estimate their actual incidence in the population. So the lower bound of our belief about actual behavior shown in the table is higher than the behavioral reports in all but two areas (light bulbs and water behaviors in year 2).[136]

Consumer Concerns and Motivations a Year after the Crisis

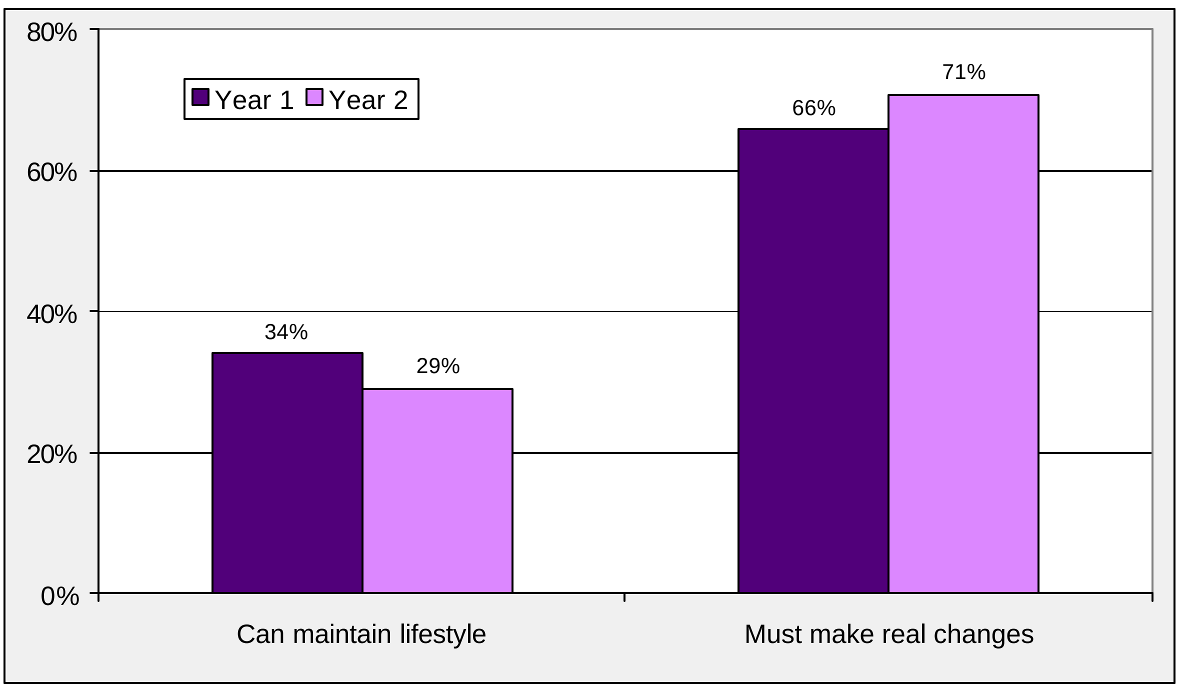
Consumers reported continuing concerns about the California energy situation, a willingness to continue conserving energy, and a seriousness about their commitments. We asked households in both the 2001 and 2002 surveys "how much have you been thinking about energy problems in the state of California and how they affect you, your family, or friends." As expected, the level of concern about energy declined, but the change was not dramatic (**Table A-8**). While those saying they were thinking about energy a lot declined from 48 to 31 percent, there was only a small increase in the number saying that they were not thinking about energy at all. This suggests that energy is still an issue for many Californians — a conclusion that is reinforced by responses to a series of attitudinal questions about energy.

For example, in both survey years we asked an identical question regarding lifestyle and energy problems. The questions was posed this way: "Which statement comes closer to your view: Californian's can maintain their lifestyle and the state's energy problems can still be solved OR Californians must make real changes in their lifestyle in order for the state's energy problems to be solved?" At least 92 percent in each sample responded to the question, and the (somewhat surprising) results shown in **Figure A-15** indicate that the majority view is that lifestyle changes will be required in order for energy problems to be effectively addressed. While we would not put much emphasis on the 5 percent increase in year two over year one, we do stress that the consistency in this response strongly supports the concept that Californian's see energy problems as having an important behavioral dimension. However, this response does not necessarily reflect a personal commitment to lifestyle change. Rather it is one of general view — after all, a respondent may think that some lifestyles have to change, but not necessarily his or her own. However, we also have evidence from questions that speak more directly to personal values.

Table A-8
Degree of Concern about the Energy Situation in 2001 and 2002

	A Lot	Some / A Little	Not at All
2001	48 %	47 %	5 %
2002	31 %	61 %	8 %

Figure A-15
Lifestyle Change in relation to Solving Energy Problems



Consumer attitudes about energy conservation were explored in greater depth in the 2002 survey than they could be in the earlier survey (which focused more directly on conservation actions and motivations). We wondered if consumers might have become skeptical by 2002 about energy conservation — perhaps presaging a post-conservation "snap-back." To the contrary, the responses to a series of questions presented in **Table A-9** seem to indicate that residential consumers in California continue to believe that energy issues are real and that energy conservation is important. In all cases, very large majorities (80 to 93 percent) offer pro-conservation responses that should have significant program and policy implications.

Table A-9
Energy Attitudes

"I really don't care much about energy and see little reason to conserve."		
Agree: 8 %	**Disagree**: 92 %	**No Opinion**: 0 %
"Even if I cared about energy, there is not very much any individual can do to conserve that will have much effect in the long run."		
Agree: 20 %	**Disagree**: 80 %	**No Opinion**: 0 %
"We could all use a lot less energy than we do and if many people conserved, we could all make a big difference overall."		
Agree: 88 %	**Disagree**: 11 %	**No Opinion**: 2 %
"Regardless of whether it makes a difference, everyone has a moral obligation to do the best they can to conserve energy."		
Agree: 88 %	**Disagree**: 11 %	**No Opinion**: 1 %
"It makes sense every once in a while to ask citizens to reduce their energy use in order to do their part to avoid blackouts and keep costs down."		
Agree: 93 %	**Disagree**: 7.0 %	**No Opinion**: 0 %
"It is worth it to pay MORE for energy in order to NEVER be asked to conserve."		
Agree: 12 %	**Disagree**: 88 %	**No Opinion**: 0 %

However, when asked whether their conservation efforts involved real sacrifices (see **Table A-10**), agreement was not nearly as strong. A little over half the households disagreed with this statement. Also, only half believed that increasing energy prices would cause everyone to become a conserver. This suggests both a measure of realism about constraints upon conservation action, as well as skepticism about the potential of price-based policies to produce widespread efficiency effects.

As we can see, continuing conservation action has some roots in belief in its necessity, and quite likely some continuing elements of altruism and general social/civic and environmental concern.

Table A-10
Conservation and Sacrifice

"My conservation efforts over the last few years have involved real sacrifices."		
Agree: 40 %	**Disagree**: 59 %	**No Opinion**: 1 %
"As energy prices increase, everyone will become a conserver."		
Agree: 52 %	**Disagree:** 47 %	**No Opinion**: 1 %

The Energy System "Problematized" – Emerging Consumer Views of Energy Issues and Energy Policies

In the opening section of this report, we referred to the persistent myth rooted in 1970s era experience that encouraged fear of consumer backlash and supported an "off-limits" status for voluntary conservation and lifestyle change in energy efficiency policy. We believe that the events in California in 2000-2002 have called that myth seriously into question. And while it may be true that Americans did not want to hear that the energy system was vulnerable (and that, consequently, the "American way of life" was not as uncomplicated as had been assumed in 1980), a lot has taken place in the ensuing 20+ years. It is our belief that, in California at least, the modern energy system has now been "problematized" — entering the realm of other, now commonplace, problems of modernity such as the clogged and dangerous highway system, air pollution and health risk, questions about the safety of food supplies, rapid spread of exotic diseases, environmental degradation and ecosystem decline, crime and crowding, and so on. In the consciousness of the California energy consumer, the energy system can no longer be taken for granted, and it may actually be understood to have potentially serious problems, as part of other large-scale systems with serious problems.

Figure A-16 presents the results of a series of survey questions about the concern for energy system-related problems. A clear majority felt that all were serious and would continue to be serious in the future. These included shortages of energy imports, transmission system limitations, continually rising costs of energy, increased pollution, nuclear waste storage, and global warming.

Rather than *resignation* to the situation, another series of questions about energy policy options suggests strong support for proactive efforts by government agencies and utilities to try to address these problems through support for continued energy conservation efforts by households, businesses, and governments. Sixty to 80 percent of households surveyed (a very high proportion) said that it was "very important" for the state to continue to support energy efficiency efforts and develop renewable energy resources. **Figure A-17** presents these results.

Figure A-16
Household Perspectives on the Seriousness of Future Energy Problems

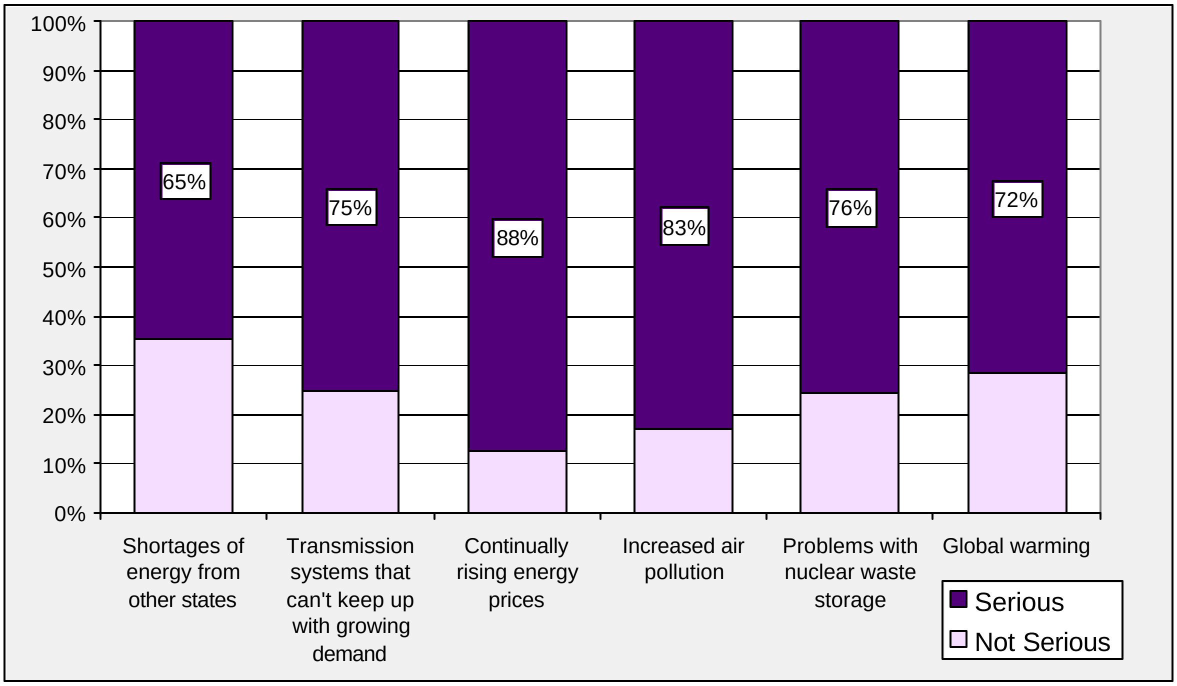
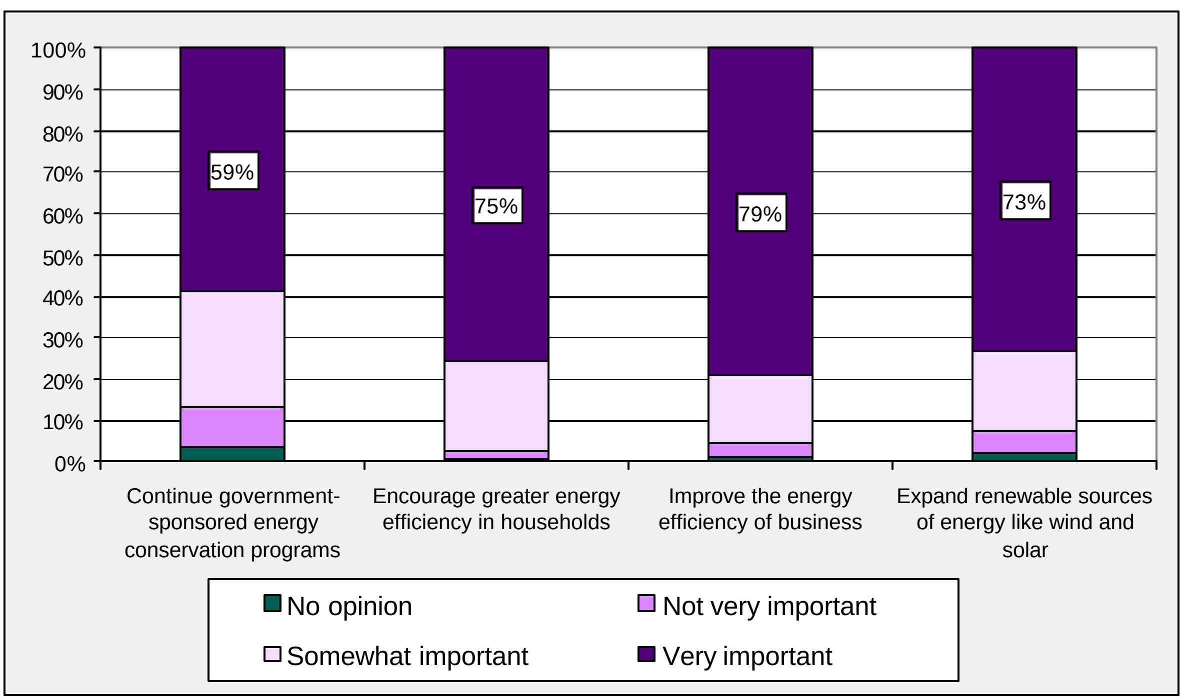


Figure A-17
Household Perspectives on the Importance of Government Energy Efficiency and Renewable Resource Action



LESSONS LEARNED AND NEW POLICY POTENTIALS

It is unlikely that anyone in California could have predicted the significant system-level reductions in electricity use that resulted from the conservation actions of millions of residential consumer households in 2001. As noted, conventional wisdom in the energy community has viewed households as relatively fixed in their demands for energy. Likewise, energy conservation behaviors have been viewed as unreliable sources of energy savings and demand reduction. Yet, the experience from 2001 indicates that electricity demand reductions resulting from conservation behavior made up the largest share of the reductions achieved. Even though the demand reduction in 2002 was not as significant, a large portion of households continued to report energy conservation behaviors.

This suggests a need to develop a better understanding of household energy behavior, so that it can be accounted for in future energy policy and program efforts of the sort that consumers would like to see. In this final section, then, we consider what we have learned about household energy behavior from the 2001 energy crisis and household behavior in 2002 that has policy relevance. We consider the ability (reliability) of households to respond to calls to conserve energy, the patterns (characteristics) of conservation response, and alternative ways to view and understand household energy conservation behavior.

Counting on Consumer Response

Consumers are clearly willing to respond positively to credible requests for demand savings in crisis or system emergency conditions. There is evidence that in the 2001 energy crisis many households remembered and applied earlier habits and patterns of energy savings, which resulted in significant electricity demand reductions. Household behavior and attitudes in 2002 suggest that these habits and patterns of energy savings, even if subsequently stopped, could be recalled in an emergency situation. The findings from our research lead to several important conclusions about the willingness and ability of residential consumers to take conservation action, under both crisis and routine conditions.

Flexibility of Household Electricity Demand

Energy forecasting, program planning and policy development all see household sector demands as largely determined by needs, desires, and comfort requirements, which are fixed in building/technology configurations, social lifestyles and individual preferences. However, we conclude from the significant demand reductions observed, and accompanying evidence of low levels of complaint and “pain” on the part of consumers, that there may be both significant amounts of redundant or wasteful energy use, and, as a result, many possible conservation opportunities, to be found even in one of the most efficient states in the U.S. (California Energy Commission 2002a).

Because residential consumption is certainly more diffuse and highly varied than that of commercial, industrial or institutional sectors, it is widely believed in energy policy circles that residential conservation response is, therefore, less predictable and more difficult to obtain (less policy-tractable), than are reactions from other sectors. In 2001, however, California consumers showed greater flexibility in their electricity demands than had previously been believed possible. A very high proportion of all households reported taking some conservation action. What's more, the majority of households reported taking several different sorts of action, exhibiting a willingness to respond to the energy crisis with some creativity and flexibility. This suggests that consumers can, under the right circumstances, react in a serious and concerted fashion. And we have seen that even small marginal energy saving effects across the entire household sector (combined with some super savers) can produce significant system-level benefits.

Wide Applicability of Conservation Actions

The largest portion of conservation actions taken also involved behavior changes that can be widely adopted by many households. Some actions (e.g., turning off a few lights) may have had limited short-term impact, but have larger cumulative effects (see Chapter 4 of this report). Other actions, such as reducing AC use, had significant effects in terms of peak load reduction, as well as longer-term benefits in reduced energy consumption. Making energy efficiency improvements to homes or buying more energy efficient appliances or products accounted for less than 20 percent of all actions taken. Opportunities to take these types of actions are limited and can be very time dependent (e.g. when a household is buying a new appliance or remodeling). So when developing energy policies and programs to reduce energy use, it is important to recognize that efforts should be made to influence and motivate households to take both hardware actions and behavior changes where each is appropriate.

Ability to Make Significant Impacts

It is important to recognize that households indicated that experience and common sense were the most important influence on the type of conservation action they took. Thus conservers were aware of and familiar with the actions they could take. They likely were putting into practice habits and patterns of energy savings that they had used before (although certainly recalled and encouraged by media messages).

Although advocacy for certain conservation targets (e.g., non-AC use) has been put off limits on the grounds that they require unacceptable lifestyle change, in California in 2001, the changes in behavior observed were often beyond those requested, and were more significant than had been imagined by state officials — often including those with "lifestyle" implications. Official calls for action and advertising messages requested "care" in energy use and a modest conservation response (e.g., "don't leave the house with the computer on," "turn off a light"). There were no messages asking residential consumers to curtail their AC use or do more with cooling than to increase AC thermostat setting levels or to appreciate the possible benefits of fans. At least 1/3 of conserver households seem to have drawn upon their common sense experience, realized that AC was the largest energy use under their control, and chose not to use AC, resulting in large reduction of their energy demands. The striking finding that few of these consumers experienced significant discomfort and negative lifestyle impacts, suggests that comfort itself is probably more elastic than imagined (Hungerford 2003). While this may be mostly true of households with particular housing and landscaping characteristics (something that our continuing analysis is considering), this is still an important and surprising finding with a variety of implications for conservation program design (e.g., regarding retrofits, non-AC cooling technologies, rethinking building design and new construction efficiency incentives).

Permanence of Conservation Behavior

Despite the relative "permanence" of hardware efficiency improvements, it is well known that these benefits often degrade with time, as equipment ages and is not routinely maintained. Energy program evaluators also have often noted "take-back" or "snap-back" effects following energy efficiency product adoption, where increased use is made of now-more-efficient equipment and new forms of consumption are added that erode program gains. Common wisdom has it that behavioral changes should be at least as likely to have "snap-back" effects, being quickly abandoned after a crisis had passed. However, the results of our 2002 survey suggest that households are continuing to take a number of conservation actions, although the mix of actions taken by each household has changed in many cases. This suggests that behavioral conservation may be longer lasting than has been commonly believed (of course, just what its "half-life" is remains to be seen).

We find the observed persistence of conservation behavior to be quite reasonable, however, given persons' positive conservation experiences and their ethical commitments. Subsequent energy price increases (although these have been applied quite unevenly across the state and within the residential rate class) are also likely to have had a reinforcing effect. Concerns about energy have certainly declined since the energy crisis in 2001. But a significant number of households are still paying attention to energy, and a large majority expressed favorable attitudes about the value and need for energy conservation. Rather than causing people to become skeptical about energy conservation, the experience of 2001 may well have reinforced its importance. The combination of willingness and ability to respond to credible requests to reduced energy demand at least suggests that households can ramp up their energy conservation activities in the case of future energy emergencies or crises. We believe, however, that considerably more than this is possible with conservers' support and cooperation.

Understanding the Dynamics of Household Conservation Behavior and Efficiency Choice: More Systematically Applying Insights from Social Science Research

Because observations of widespread, flexible, and at least somewhat durable conservation action calls into question conventional assumptions about the nature of electricity demand, these findings also open some new avenues for program planning and policy development.

As we have noted, conventional efficiency thinking assumes that the most effective conservation policies are ones that promote improvements to appliances, household technologies and buildings. So it was hardly surprising that hardware solutions were heavily promoted by state agencies and utilities in California during and after the 2000-2001 crisis. However, the demand reductions observed in this study were largely due to conservation behaviors promoted by a social marketing campaign that would have been unthinkable to energy planners were it not for the crisis.

The observed demand reductions suggest that there is a need to rethink the role(s) of the consumer in securing energy efficiency benefits. To deal with this new actor on the policy landscape, we need to better understand how, when and where s/he might be willing to curtail energy use in emergencies, to reduce or shift loads during times of peak demand, to purchase and effectively use higher efficiency equipment, and to routinize the frugal use of energy in concert with efficiency investment. As we noted in the beginning of this report, there is a fairly extensive literature on consumer motivation, choice, energy use behavior, and conservation action that has not frequently been applied to energy efficiency program design. While we do not summarize that knowledge base here, we do draw upon it in suggesting that the flexibility and responsiveness of consumer action can be much better understood with a little effort, and that this understanding can, indeed, inform the development of much more effective energy efficiency policies — policies with "Epoch 3" characteristics of complexity, community, and partnership between energy users, energy providers and state agencies.[137]

The Concern, Capacity and Conditions Model

In earlier research supported by the Energy Commission, we have drawn upon the literature to help understand why some energy users adopt conservation and efficiency practices and devices, while others do not — even when the desired innovation may be proven cost-effective. We have concluded that conservation and efficiency adoption depends upon the consumer's (1) level of concern, (2) his/her capacity to act, and (3) the conditions and constraints surrounding that action.[138]

For example, we know from our surveys that there was a high level of concern about the energy situation and a widespread commitment to conserve among residential consumers in California in both 2001 and 2002. So concern — the first crucial ingredient — was in place for most households (and where persons were not concerned, no action was either expected or observed).

At the same time, we can see that residential consumers vary widely in their capacities to act. Despite one's level of concern, without specific capabilities (e.g., appropriate hardware knowledge, ownership of the target appliances and/or buildings, market access to efficiency technologies and installation services, having the cash or access to credit, etc.), hardware action was not possible. In fact, we observed a different likelihood of efficiency investment depending upon home ownership, income, and related factors. However, these limitations did not stop persons from making behavioral changes when hardware changes were not within their capacities. In fact, previous knowledge and habits of frugality could be reactivated, and these did not require any investment. We believe that, where requisite knowledge and habit were not present (regardless of concern and even financial means), significant conservation and efficiency improvement were also absent.

Finally, even when concern and capacity are present, the conditions surrounding choice (i.e., context factors and constraints) such as lack of time, competing claims on attention, uncertainty about length of residence in a dwelling, and the constraints of existing housing and technology, can shape (and, most frequently, limit) efficiency choice. In the residential sector, hardware response is normally very constrained by household capacity and conditions. This is why efficiency improvements are relatively unusual, even with the availability of rebates, incentives, and tax credits. During the crisis, the immediacy of the need for a conservation response dictated that it would necessarily be a behavioral one. And even when hardware purchases were made, they were reported to accompany a range of behavior changes.[139]

New Imagery and New Conservation Potentials

If we are coming to see consumer behavior as a potentially significant element in energy policy, and if we can understand that conservation and efficiency choices are strongly shaped on the consumer side by concern, capacity and conditions (the "three C's"), then we are opening the door on new *imagery* — new ways of thinking about, conceptualizing, imagining, seeing energy use and the energy user. When we move to a more realistic notion of how persons and their machines, and persons and their buildings interact with one another in natural and built environments, we can see a variety of features of that re-imagined world that are salient to energy policy. Here are a few of these.

Moving Beyond the Efficiency Measures Framework

As we have repeatedly noted, the vast majority of residential energy efficiency programs focus on encouraging the adoption of more energy efficient technologies in dwellings. The adoption of energy efficient technologies can be measured and accounted for. There can be a tendency to view energy conservation behavior like energy efficiency measures. There can be a desire to define and measure behavior in ways that are similar to energy efficiency measures. Yet the fluid nature of energy conservation behavior makes it difficult to define and categorize in this way. It is challenging to determine when it is occurring and the extent to which it is occurring. For example, if a household was asked to report energy conservation behaviors, would they report a behavior like turning off lights that they have always done, but may not be doing diligently now? How diligent would they need to become before they might report the behavior?

Likewise, behaviors can be described in different ways. For example, a household could report they are using less AC. Or they could report they are using fans, shutting blinds, opening windows or any combination, all of which could reduce AC. Even if a household were to just report they are using less AC, it is likely they are taking some other actions to compensate for using less AC.

The energy savings from a particular conservation behavior vary depending on the circumstances and household diligence pursuing the behavior. If there is a desire to identify a change in energy savings, there is a need to identify previous levels of conservation, which is likely to be difficult. Any savings are also likely to be small and within the normal variation of household energy use.

All these issues make it difficult to define and categorize energy conservation and savings at a *measure* or *household level*. But in *aggregate*, many small changes do add up. The experience from the summer of 2001 indicates that demand reduction from energy conservation behavior can be real and substantial. The ability of large numbers of households to modify energy behavior helps to mitigate uncertainty and risk associated with the savings from these actions. Rather than trying to explain this behavior using an energy efficiency measure framework, the results of our research suggest that we need to develop alternative ways of understanding energy conservation behavior.

Energy Conservation Behaviors in Households are Widespread and Evolving

Energy efficient technologies tend to be fairly tangible. They are either present or not. However, energy conservation behaviors are not as discrete and tangible. Common conservation behaviors are not typically just turned on or off. For example, consider turning off lights when not in use. Most households are somewhere between the extremes of leaving their lights on all the time and diligently turning off all lights in unoccupied rooms. During the energy crisis, many households increased their diligence turning off their lights. Likewise households typically don't leave their AC on all the time. They have habits that they use to limit their AC use. These can be past experiences (when they did not have AC) or they can be new habits (using the new thermostat to control the AC). Some households might rely on these habits more than others and this may change over time. So people draw on their past and current experiences and their actual energy conservation behavior can occur across a wide spectrum. This can change and evolve. It is not static or discrete, but is more continuous. It ebbs and flows. The key point is that these energy conservation behaviors exist to some degree in households, and this latent capacity can be utilized. There is some flexibility in household energy demand.

Energy Conservation Behaviors are Part of how Households Manage and Routinely Use Energy

The context for energy conservation behavior fits within the way households are managed and operated to meet the needs of the people living in the homes. To understand energy conservation behaviors requires understanding household patterns of energy use and how households manage their energy use. Households have a set of existing energy habits and behaviors that can be viewed as their *plan* for managing energy use. How households follow through with their *plan* reflects how energy conserving they are. Due to a variety of circumstances, households can do things that may not follow their *plan* and that increase their energy use (for example, forget to shut windows during the day or setback the thermostat). During the energy crisis, household may have returned to their *plans* and managed their energy use better. And they may have modified their *plan* to eliminate habits that were increasing energy use. In this manner, households learn new patterns of energy use. The patterns that meet their needs and either enhance or maintain comfort are likely to be incorporated into the household *plan* for energy use. Over time, a household may become more lax in following the *plan*, but a change in circumstances can lead to more diligence in executing the *plan*.

The Ability of Households to Act can be Enhanced by External Influences

The events of the 2001 energy crisis illustrate that households can be influenced by external factors such as the media to become more diligent in their energy conservation behaviors. The events of 2001 raised household awareness and concern about energy and made this a relevant issue for them to act on. Households responded primarily by taking a variety of energy conservation actions depending on their circumstances and capacity. These are actions that can widely be adopted and in many cases fit within the *plans* and experiences households already had regarding energy. Hardware type energy efficiency measures were less common because the capacity or conditions severely limited the ability of many households to take these actions. The ability to shape and influence household energy behavior provides a significant opportunity for demand reduction.

Fundamentally, what we are suggesting is that energy efficiency actions in households are not isolated events, but need to be understood in the context of patterns of household energy use and the factors that shape the ability of a household to act (concern, capacity, and conditions). These patterns and circumstances are changing and evolving and can be shaped and influenced. This flexibility in energy use across large numbers of households can be taken advantage of to enhance the effectiveness of energy policy and energy efficiency programs.

Incorporating Consumer Response in Policy Strategy

Starting with the concern, capacity and conditions model, we draw upon the literature[140] and the empirical evidence from 2001-2002 to elaborate the model a bit before applying it to a range of policy strategies — all of which are currently under discussion in one form or another in California.

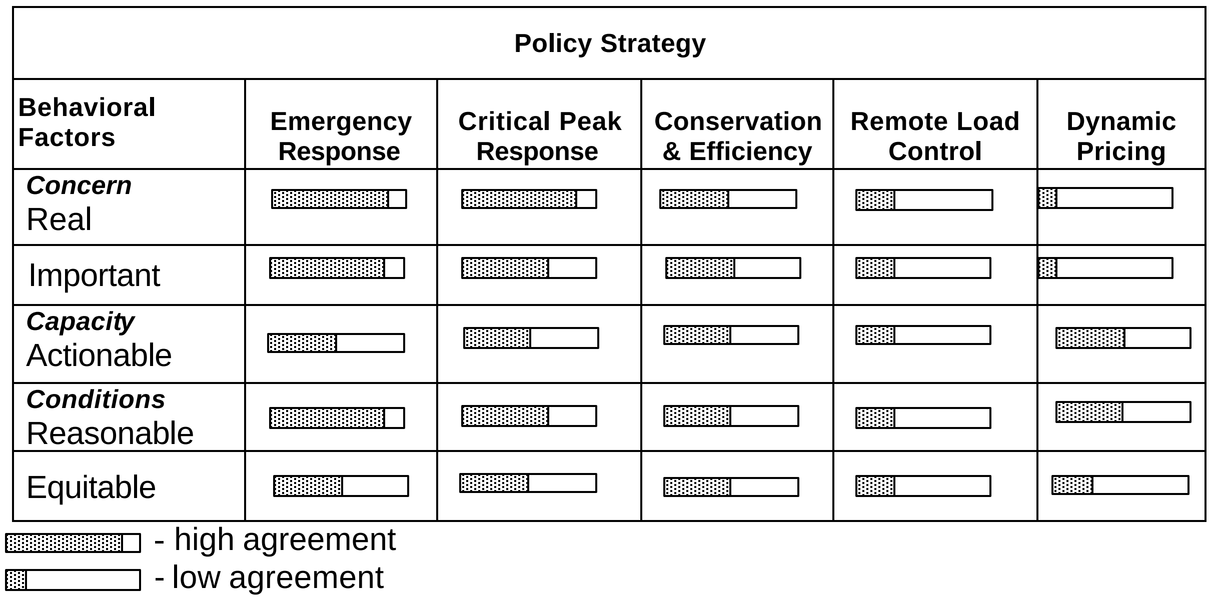
Although we might imagine capacity and conditions to be less "subjective" than concern, in fact all of the "three C's" are heavily dependent upon persons' understandings and interpretations of their situations. The rise and fall of effective programs and policies depend heavily on this, often-overlooked, fact. So in considering some of the policy options now under consideration, it is important to use a more somewhat elaborated three C's model that takes this fact into account.

For example, consumers' *concern* can be seen to rely on at least two cognitive factors: a belief that the problem at hand is actually *real*, and a perception that it is *important* enough to warrant attention. Obviously one can imagine a problem described by public officials to be real, while at the same time it may seem to be unimportant, engendering little concern. And one often hears of problems that would be important, if only we could believe that they are as real as their advocates claim.

Also, the *capacity* to act is present if, and only if, the consumer believes that his/her personal action is *possible* — that s/he has options that *can be implemented* and that *will have effect* in the real world. I may be concerned, but I may not see anything that can be done. Finally, the *conditions* that permit action to occur can be said to exist if, among other things, the request for consumer participation is seen to be *reasonable* (e.g., it may be reasonable to ask persons to turn off unused lights, but perhaps not to unplug their televisions). What's more, a key condition is that the requested response is seen to be *equitable* (i.e., that the consumer is not being asked to contribute beyond his/her means and significantly more than others who are "doing their part" for the common good).

Figure A-18 depicts a speculative exercise in how the concern, capacity and conditions model (elaborated by including the sub-issues of realism, importance, actionability, reasonableness, and equity) may vary across some policy strategies currently under discussion, having different implications for the success of each strategy. In each cell, a bar that represents a best guess from our data and the literature indicates a likely level of agreement in the population at this point in time with those five characteristics of the policy option. Bars that are mostly *shaded* are meant to indicate a high level of agreement with the realism, importance, etc. of the energy problem and the solution represented by each policy strategy. Bars that are mostly *unshaded* suggest likely low levels of support on those particular dimensions. The relative shading of these bars is not meant to indicate real, measured, quantitative differences in the population. Rather, they are presented together in the figure that can serve as a heuristic device to help us think about relative levels of agreement — and therefore consumer response potentials — across salient dimensions of current policy options. In the discussions that follow, we consider in greater detail how consumer response might vary along these dimensions, with varying implications for policy success.

Figure A-18
The Bearing of Behavioral Factors on Policy Strategies



Emergency Demand Reduction

It is fairly clear that California consumers understand that the energy system is not failure-proof and that energy emergencies (e.g., from lightning strikes, transformer and transmission line failures, etc.) do sometimes occur. Our respondents seem willing to curtail at least some energy uses during emergencies to assure system stability, and they do not seem to be willing to pay premium prices to try to assure 100 percent reliability in the system. They responded effectively to various emergency events during 2000-2001, and they say that they are willing to do so in the future. We think that they ought to be believed in this, since the evidence from attitudes, behavior and demand response is all in agreement. Not all consumers are likely to see that they have many action options, however, and at least a few (the elderly, disabled, low-income) may not perceive curtailment requests, even under emergency circumstances, to be fair and equitable. Their energy use may be quite small in comparison to others, and they may perceive a need for uninterrupted energy service (e.g., for cooling) because of health conditions and poorer housing quality.

Critical Peak Response

During the 2000-2001 power crisis, persons were asked to consider reducing energy use during critical periods (e.g., during Stage 1 and 2 alerts). We have not examined peak system load data for those periods, so we have no conclusions about the effectiveness of those requests. General calls for peak load reduction and load shifting through the *Flex Your Power* campaign did result in both reports of conservation response and peak shifting, along with system-level reductions in peak that exceeded state goals and likely prevented more alert days and rolling blackouts. However, relatively few of our respondents reported peak shifting activities, compared to a wide array of other actions. Overall reductions in energy use through conservation certainly do contribute to lower peak demands by contributing households. But while a substantial majority of respondents (73 percent) reported being aware of at least some alert notices, only about 40 percent reported that they *had taken action* in response. This is only slightly surprising, since many persons are not at home during what they understand to be alert periods, while others are not aware of alerts, didn't feel that they are able to do anything (or anything efficacious) during an alert, or simply didn't care.[141]

For this reason, **Figure A-18** suggests that high levels of concern and agreement about the reality and importance of a declared energy system emergency, may be accompanied by lower levels of capacity to act and perceptions of the reasonableness and equity of calls for universal demand reduction in response to system-level supply problems (whether these have to do with physical shortages or high prices).

Conservation and Efficiency in Non-Emergency Circumstances

Despite nearly two decades of state and utility-sponsored, mostly hardware-focused, energy efficiency programs operating in all localities across the state, our survey respondents reported low levels of program awareness in 2001. Only about 39 percent were aware of energy conservation programs available in their locale, and we used a very liberal definition of "program," allowing respondents to identify *any* activity as an energy program. Of this number, only about 1/4 (7 percent of the total population) reported participating in or benefiting from such a program.

Even granting faulty memory, confusion, etc., it is clear that there are opportunities for better informational efforts to support efficiency goals — particularly if the primary instrument of public policy in this area remains the utility or locally sponsored efficiency program. It also suggests that program inclusion criteria and benefit levels may both explicitly and de facto work to exclude a wide array of households and household types. In our depiction in **Figure A-18**, we graphically represent consumer response to the continuation of the "shotgun approach" to efficiency (e.g., refrigerator rebates that come and go, locally variable CFL buy-downs, home energy audits for high bill complaints, websites with links to programs and information, low-income energy assistance) as a mixed bag. There is evidence of real concern about energy and related environmental issues, but likely a lack of agreement about whether energy efficiency programs as we know them are real responses to known problems, as well as whether the problems they are addressing (e.g., resource acquisition cost differentials) are truly important, if purchasing a more efficient piece of hardware (that may also be larger) is an efficacious action, whether action is possible at all (e.g., if the household has $700 needed to go with the $50 refrigerator rebate), or whether reason and equity are best served by the program approach. These issues are all matters of debate among energy and environmental policy analysts, and it would be surprising if the general public would be less ambivalent, despite their concerns about the important underlying problems.

We believe that our findings and the new perspectives on the importance of consumer behavior in energy policy that they suggest indicate the potential value of new approaches to thinking about *ongoing efficiency efforts*. We do not at all propose to replace hardware-focused efforts with behavioral ones. However, we know that there are significant behavioral effects on hardware operations and on hardware acquisition, as well as effective behaviors (i.e., following the household's "plan" or desired habit patterns with conservation in mind) that can work in concert with more efficient hardware. We know that new uses of energy can cancel the gains from improved hardware efficiency, and that exuberant energy usage (observed in some households even during the crisis) can swamp the benefits of the most efficient dwelling and equipment. We can see that some persons are equipped with outdated devices, but that they are among the least likely to replace them. We know that behavioral responses, as well as "low-tech" practices (e.g., the use of fans and management of shading for cooling benefits, rather than either low Seasonal Energy Efficiency Rating (SEER) or high SEER central AC units), are all that are available to many households because of their capacity and condition constraints.

There are implications of all of these observations for ongoing efficiency policy, *if we really want this policy to be* optimally *effective* — and this is not a given, since truly effective programs would erode revenues to utilities and the state, requiring *increased* energy charges to cover the "stranded" costs of old, dirty, and inefficient power plants and the state's long-term power contracts negotiated under duress. However, if we really want the optimal impacts and optimal social and environmental benefits of, for example, lower per capita energy use in the future, we should probably be thinking about efficiency initiatives that are campaign-based, problem-focused, consumer-centered, and complexly integrative (i.e., that coordinates a range of behavioral, hardware and hardware + behavior interventions).

We consider each of these features and put them in the context of an example. The success of the *Flex Your Power* campaign, an approach that would never have been attempted under pre-crisis conditions, as well as the high levels of recognition of the Energy Star™ brand and reports by our respondents that 3/4 considered energy in recent hardware purchases, indicate that media is key to widespread awareness, and that focused messaging and branding can be important — and may be *crucial* — for problem recognition and program success. Concerted campaigns may be required to allow consumers to recognize the reality and importance of energy system problems and the appropriateness of the proposed solutions — to link their general concerns about energy with particular issues and outcomes. For example, a focus on specific problems related to peak demand threats to the system or increasing environmental pollution, provide focus and lead to agreement on particular goals/solutions (e.g., reducing cooling loads, cutting back on emissions).

Knowing something about the consumer realities allows tailored program designs as well as effective messaging. We have noted the differential capacities of consumers to act (based on income, age, housing conditions, and existing hardware), as well as a range of limiting conditions (e.g., involving time horizons, risk perceptions and tolerance, perceived reasonableness and fairness of conservation/efficiency requests). All need to be thoughtfully taken into account in policy analysis and program design, and a variety of different ways for persons to contribute to collective problem solving need to be devised and offered to consumers. Sorting out the implications for policy of consumer heterogeneity will require further detailed research, as well as a planning process that is open to lay participants.

An example might be a campaign and array of conservation/efficiency offerings related to residential cooling. **Table A-11** presents a thought experiment about what such an initiative might involve, perhaps expanding the New York state "Keep Cool" campaign (Hammer and Maxwell 2003), or at least adopting that very nice label or something like it for a much broader effort than that underway in New York.[142]

None of these program elements is particularly novel, and, in fact, creative minds (including consumers themselves) and careful analysis could undoubtedly develop others. However, the key to improved conservation and efficiency efforts under non-crisis (business-as-usual) conditions, we believe, is to offer an integrated portfolio in a coordinated fashion — getting the right incentives/services in front of different consumers, by taking consumer concerns, capacities and conditions carefully into account.

Remote Load Control

Beyond enhanced conservation/efficiency response, two other policy approaches are currently receiving a good deal of attention. Both have been around for over two decades, although neither has been widely practiced. Both are targeted specifically at the peak demand problem. The first involves remote control by the utility of household equipment, primarily central air conditioner cycling (but also fairly widely used by utilities for electric water heater cycling and in some instances for electric heat with storage media). The earliest implementations of the technology were completely "top-down" and designed to be used during critical peak periods. These have given way in some cases to equipment with automated controls that can either be programmed to disable equipment such as electric hot water heater or pool pumps during some or all peak periods, or to elevate thermostat setting during peaks for AC equipment. The locus of control can either be at the utility or at the residence.

We have not thoroughly investigated the literature on remote and/or automated residential load control at this time, but are aware of some fairly significant participation levels in AC cycling programs (e.g., the SMUD "Peak Corps" program), as well as anecdotal information about expected attrition from these programs during hot spells. In any event, an irony of all peak load reduction efforts, whether these be behavioral or remote/automated in nature, is that they are most needed by the system *at precisely the times when cooling is most needed by the consumer*. In **Figure A-18**, we hypothesize relatively low levels of acceptance of peak load control across all behavioral factor categories, in part because of the tension between system benefits and consumer desires, concerns, capacities, and conditions — all of which are exacerbated as environmental heating increases, as does demand for energy. On the other

Table A-11
A Hypothetical California "Keep Cool" Campaign

Problem
Peak energy demands on hot days strains energy delivery capacity, contribute additional pollutants during poor air quality periods, and expose the system to often-high and sometimes erratic spot market energy costs. Residential cooling loads are a primary contributor to all of these problems.
Solution
Reduce residential cooling loads, particularly demands from compressor-driven central AC systems. Based on technical potential studies (e.g., Ruffo 2003), we know that residential cooling has much to contribute to overall efficiency gains. Based on our own research, we know that non-AC cooling behavior was adopted by a significant number of consumers, and that it has continued to be adopted after the crisis.
Marketing approach
• Develop awareness of connections between peak load/system problems and background concerns about energy supplies and environmental impacts. • Establish an appreciation that the problems are real, important and actionable. • Create brand identification, for example linking "Keep Cool" (or some other significant label) and Energy Star™ as elements of a broad campaign to address collective problems with common efforts — where persons can all "do their part," in a variety of ways.
Program design
Based on consumer research, knowledge of technical potential, and program experience, design and launch a portfolio of programs that simultaneously target hardware, behavior and hardware + behavior changes to optimize results. These programs would provide opportunities for households with different circumstances and constraints to participate in different ways. As household capacities and conditions change and evolve, there will be new opportunities to take part in various program offerings. Elements might include: • Television news/weather coverage and video documentaries analyzing energy and environmental problems, and identifying the connections between cooling and peak loads as particularly problematic • Advertising that promotes behavioral as well as investment solutions to the peak problem; celebrate "low-tech" but common sense approaches, such as turning off lights and other interior heat-generating equipment, managing curtains and blinds to keep the heat out, managing windows to cool at night and vent accumulated heat in the evening, using fans in a variety of clever ways, etc.; continuous linking with Energy Star™ • Educational materials in K-12, as well as community-based information efforts focused on cooling and peak, and various feasible household responses; community-level forms of the campaign tailored to local conditions and opportunities (that vary widely across the state) • Subsidized, high quality whole-house energy audits and retrofit planning with particular focus on cooling loads and peak benefits • Revived programs to increase insulation levels, seal ducts and install cool roofs, thermal barriers, and improved windows, etc.; supply appropriate incentives (subsidies, tax credits, rebates, etc.) • Bring to market non-compressor cooling technologies, including night venting and evaporative cooling • Promote and incentivize replacement of existing central AC units with higher SEER models • Aggressive pursuit of appliance standards and building codes that take peak demand and residential cooling efficiency improvements into account • Focused efforts to build the industry infrastructure necessary to deliver a new level of "green building" services to millions of homes in need of significant retrofit (since they were designed and built assuming economic, social, technical, and environmental conditions that no longer exist) • Integrated new construction program that brings together building techniques, high efficiency cooling, non-compressor cooling, labeling/branding, and marketing/builder incentives to produce more cooling efficient homes

hand, there is no reason in principle that load control could not be an effective ingredient in the kind of large-scale cooling campaign outlined in the previous discussion. For example, there are ways to minimize the comfort impacts of AC cycling by precooling during off-peak periods. There are also load control strategies for equipment such as electric hot water heaters that have minimal comfort impact.

Dynamic Pricing

Significant attention is now also being given to dynamic pricing of electricity as a means of addressing peak load problems. Under dynamic pricing (DP), different per kWh charges apply at different times of the day, with the peak (variously defined) being the most expensive, and the middle of the night the least. Under some policy approaches, this *time-of-use* rate is supplemented by a very high rate charged during critical peak periods when electricity is in short supply and/or is very costly. The logic of DP is that it serves to reward load shifting with lower energy costs, it discourages on-peak energy use with higher prices, and if those prices are paid they will help to compensate the system for higher marginal costs of supplying loads during peak periods. As a result, DP represents a fairly significant renegotiation of existing understandings between consumers, utilities and the state.

This report is not the place to fully consider the costs and benefits of DP in the residential sector, and that debate is ongoing in the energy policy community. There are several points that bear mention, however. The first is that, as a single *non-programmatic* solution to peak load problems, DP is probably a fairly blunt instrument. In the extreme "market-based" view of DP, a variable "price signal" is given to the entire population of consumers via their monthly power bills (with or without clues about how to effectively reduce consumption and shift peak demands), and some aggregate response is expected. Measured overall demand reductions can be correlated with price levels and an "elasticity" of demand calculated. After making some fairly heroic assumptions about the non-historically-specific nature of the underlying behavioral response (i.e., that it is reproducible in magnitude under later conditions), and the unimportance of distributional differences in response (e.g., between the rich and the poor), the elasticity coefficient can be used to manipulate prices in order to gain a predictable reduction in peak demand. In the most extreme forms of the market-centric view, the mechanisms (i.e., the consumer responses) that underlie the DP response are not really of interest. People will simply take care of themselves as best they can. In more moderate forms of the view, issues of equity, information, and technical potential are allowed to enter the discussion.

From our own "bottom-up" consumer-centric point of view, there are a variety of reasons to question the efficacy and fairness of DP in the residential sector. Consumers may be skeptical of the realism of the problem (usually presented as a "peak cost of supply" problem) and of its importance, as well as how effectively they can be expected to respond, and whether the expectation of continuous peak-shifting and peak-reducing behavior changes on their part driven by shifting prices is reasonable and fair.

In order to avoid inequities, DP policies would need to undertake at least some targeted educational efforts among those who can least afford to incur large costs from failure to shift peak usage. Ninety two percent of our sample had heard of “the peak energy use problem,” and 63 percent had actually attempted to reduce their energy use at least once during a peak. However, only 61 percent could correctly identify the peak period as being in “the late afternoon,” with the remaining 39 percent (a fairly significant proportion) either incorrectly identifying the peak as being “in the morning,” “around noon,” or “at night,” or they admitted that they didn’t know when it was.

Drawing on our findings, we also wonder whether the various DP rates under discussion can really provide demonstrable cost savings to consumers that are sufficient to act as a motivator. While overall energy costs are concerns to consumers, detailed price information was not seen as particularly important. Our respondents indicated that concerns about cost were only one of many motivations to conserve energy, and survey responses about energy bills indicated that about 1/3 do not even see their power bills (e.g., since these are paid by a spouse, by automatic deduction from bank accounts, paid in the rent, etc.).

Successful load reduction/shifting as a result of DP depends upon a variety of consumer behavioral responses: first, the willingness to opt into those rates (unless they are imposed), and second, the willingness and ability to make changes in energy usage and control, and to invest in either more efficient or load-shifting equipment. Our research would suggest that there is willingness to conserve, particularly under exceptional circumstances. Consumers also recognize that energy system problems have become a fact of life. So they can, in principle, see the logic of being “demand responsive.”

However, consumer concerns about affordable energy services would also suggest that DP policies would have to provide demonstrable cost savings to consumers, while not resulting in what might be perceived to be either excessive or unfairly distributed costs and benefits. At this point, it is not clear that significant cost savings accrue to participants DP experiments,[143] or even that cost saving is the primary motivation for participation (in at least some cases, altruistic and environmental motives have certainly had an influence in participation rates).

Studies of time-of-use experiments have shown fairly universal satisfaction with these rates and associated shifts in demand. But DP experiments also show fairly low rates of volunteering for such programs, and that some customers’ demand patterns result in greater savings than others.[144] Overall demand reduction may be small with “opt-in” or even “opt-out” tariffs. It may require a universally imposed rate to achieve desired system-level savings, but in this event may also bring with it unwanted equity impacts from uneven ability to respond, as well as new costs of administration. And finally, a number of observers have questioned the availability of significant system-level benefits from DP in the residential sector, particularly given the costs of acquiring data and supplying customer education and information.[145]

Because of all of these factors, we speculatively rate agreement as “low” across all behavioral factors in the Dynamic Pricing column of **Figure A-18**. While the jury is certainly still out on DP, we believe that there may be better alternatives (e.g., various tested forms of remote and automated load control) to achieving the benefits of a more demand-responsive system. However, we can also imagine carefully crafted DP rates, along with load control technologies, as elements in an overarching efficiency and conservation campaign of the sort suggested earlier in this report.

Strategic Information for Policy Development: An Expanded Role for Social Science Research

If we are to take the lessons of the 2000-2002 California energy crisis and its aftermath seriously — and as a result, bring the consumer more fully into the energy policy picture and planning process — further social science research is required. In short order, we will need to develop a much better understanding of consumer motivation, energy use behavior, conservation action, and efficiency choice.

The research reported here, as well as the existing literature, demonstrate that these are complex, intricate and dynamic processes that are not well understood. The need for serious research in this area has been noted repeatedly over the course of the past two decades (e.g., Stern and Aronson 1984, Lutzenhiser 1993, Shove et al. 1998). Also in non-energy areas such as the analysis of environmentally significant behavior (Stern and Dietz 2002), economic sociology (Lutzenhiser 2002), and behavioral economics (Dubner 2003), there are calls for a broader range of research focused on consumer-side dynamics and policy potentials.

This research should focus on developing a better understanding of the context for household energy efficiency action. This includes examining patterns of household energy use, how energy habits and knowledge result in a *plan* for managing energy use, the changing nature of the household *plan*, and how household energy *plans* can be shaped and influenced. The application of the concern, capacity, and conditions model to household energy behavior needs further review and refinement. In this we emphasize the need to better understand the *management* of household energy use, rather than individual actions or decisions.

As we reported here, there are a variety of unique challenges involved in the study of household energy use and conservation behavior that have required a number of innovative data collection approaches and analytic techniques. The use of open-ended survey questions to collect information on energy conservation actions presented a variety of analytical challenges. However, the results revealed the fluid nature of conservation action and the difficulties in defining it. This reinforces the limitations of using close-ended surveys to collect information on energy behavior and the need to develop and apply new data collection and analytic techniques to research in this area.

There are more detailed data needed that we have not been able to collect because of time, resources and the problems of "survey fatigue." Although our analysis continues, there are points where both data limitations and actual findings leave us with inconclusive results.

These include our inability to date to identify as much behavioral clustering as we had expected, and limited success in relating specific behaviors to particular demographic groups. On the other hand, our findings that conservation response was widely performed across a highly diverse population, while at the same time there are significant differences among households in their abilities to actually save large amounts of energy, are of considerable importance, since they point to a receptive population and a large as-yet-untapped (although, also certainly not easily-tapped) reservoir of energy savings in the residential sector.

The next steps in our current research include examining changes in consumption, including persistence of savings and "snap back," controlling for weather effects, across the entire 1999-2003 period. We are analyzing patterns of energy use and conservation using multivariate models that take into account building characteristics, technology, weather, demographics, and conservation action in estimating the contributions of each during and after the crisis. Finally, we are considering changes in cooling practices and other adaptations (both behavioral and hardware-oriented) being made by a small sample of households who are currently enrolled in an Energy Commission-sponsored DP experiment. We are particularly interested in developing a better understanding of variations in patterns of household energy use, in how people manage their energy (and energy using/saving plans), how people modify their habits and strategies in response to different sorts of stimuli (social concern, self-interest, price, policy, media messages), and how all of these differ across socio-demographic groups.

In all of this work, we are attempting to extend our knowledge of the significant role played by consumers in the shaping of their own energy demands, under a variety of changing social, economic, environmental, and public policy conditions. The experiences of the California energy crisis illustrate the potential value of this knowledge for fully taking advantage of the energy efficiency and demand responsiveness of households. As Epoch 3 of environmental problem-solving unfolds in the U.S., California is, once again, poised to emerge as a leader. This time with energy policies that move well beyond both hardware and markets.

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APPENDIX B: EFFICIENCY

CALIFORNIA'S CURRENT EFFICIENCY PROGRAMS

The investor-owned electric and gas utilities, municipal utilities, and the Energy Commission are the primary agencies responsible for delivering energy efficiency programs in California today. The future role of local governments and other state agencies may be increasing in response to evolving CPUC policies. A description of the current programs offered by the primary energy efficiency entities follows.

Investor-Owned Utilities

The investor-owned utilities administer 14 statewide electric and gas programs intended to share program design, targeted measures, incentive levels, savings assumptions, and evaluation methods across all service territories. For 2003, approximately $270 million will be spent on statewide and local programs, third-party programs, marketing and outreach, and evaluation. The primary end-use targets for these programs are:

- Lighting & Appliances,
- HVAC Systems, and
- Motors.

The utilities also administer programs that encourage energy efficiency for home retrofits and renovations, and during the new construction of buildings and homes. Most of these programs are funded through the PGC; others are funded through special purpose legislation. An example is Senate Bill X1 5, also known as the *Summer 2000 Energy Efficiency Initiative.*

These programs typically target particular end-uses within a market segment using a combination of information, energy management services, incentives, and upstream programs targeted at distributors and manufacturers. There is an emphasis on leveraged efforts, especially with the federal ENERGY STAR® program.

Another group of "cross-cutting" programs emphasizes education and training in support of the hardware programs. These efforts cut across all market sectors and aim at improving the upstream sales and distribution of energy efficient products, increasing awareness of products through marketing and outreach, demonstrating emerging technologies, and supporting upgrades and enhancements to the building and appliance standards.

In addition to the statewide programs, the CPUC awarded $117 million from 2002 and 2003 PGC funds to seventy programs dedicated to providing energy efficiency measures at the local level. These programs are being offered for two years by a combination of governmental entities, non-profits and community-based organizations, small businesses, consulting firms, investor-owned utilities, and other entities. Administrative oversight for these programs is assigned to the investor-owned utilities.

Municipal Utilities

Municipal utilities provide approximately one-quarter of the electricity consumed in California. Public utilities typically offer programs across all market sectors using information, audits, rebates, and financing to promote efficiency. Renewable energy, low-income, and R&D programs are included among municipal utility program offerings. Several of California's public utility programs garnered awards recently from the American Council for an Energy-Efficient Economy as exemplars of "best practices."[146]

Investments in public benefit programs by public utilities are based on a legislated formula, but some municipals elect to spend more than is required. SMUD, for example, invested $6 million more than was required in 2001. The Energy Commission conducted a survey of twenty public utilities in 1999 and found that California's public utilities had budgeted approximately $102 million for public benefit programs.[147] Energy efficiency and low-income assistance received three-quarters of the funding, followed by research and development (10 percent), renewable energy (9 percent), and public education (5 percent).

California Energy Commission

The Warren-Alquist Act conferred on the Energy Commission a range of public purpose programs intended to stimulate the market for energy alternatives that were less polluting, less reliant on imported fuels, and less consuming of finite natural resources. The Energy Commission also promotes reduced energy consumption and increased efficiency through periodic upgrades to the building and appliance standards.

Building and Appliance Standards

The Energy Efficiency Standards for Residential and Nonresidential Buildings set minimum levels of insulation in new construction and minimum levels of efficiency for windows, and mandate installation of efficient equipment, appliances, and lighting. Changes to the standards, occurring in three-year cycles to coincide with changes to the complete building code, account for improvements in conservation technologies, changes in the cost of fuels and energy-conserving strategies, and improved capabilities in analyzing building energy performance. The latest revision to the standards emphasized peak demand savings and went into effect on June 1, 2001. New Outdoor Lighting Standards are targeted for adoption October 1, 2003.

The Energy Commission coordinates the investigation of new standards ideas through PGC-funded research conducted by the utilities and their contractors. More than half of the new measures proposed for inclusion in the 2005 Standards are being tested and evaluated through the utilities' PGC-funded Codes and Standards support program.

Appliance Energy Efficiency Standards assure consumers that appliances they purchase in California meets minimum state or federal efficiency guidelines. The end-uses most affected by the Appliance Standards are refrigerators, air conditioners, heat pumps, gas furnaces, space heaters, water heaters, plumbing fittings, and fluorescent lamp ballasts. The Energy Commission conducted an expedited rulemaking process in 2001 to respond to trends in electricity peak demand. Most of these new minimum efficiency standards became effective on March 1, 2003.

Energy Commission Programs

The Energy Commission received $377 million in 2000-2001 legislative funding to implement programs that would provide "immediate benefits in peak energy demand reduction and more efficient use of energy."[148] Twelve new program elements were launched under a broad program known as the Peak Load Reduction Program beginning in the fall of 2000. Roughly 565 MW of new peak savings had been installed as of December 31, 2002.[149] As these programs wind down, the Energy Commission's program emphasis is returning to energy efficiency technical assistance and loans for public agencies (especially local governments and schools), water, industry and agriculture, and support for the building and appliance standards.

Collaborative Programs

The current public benefit programs offer several examples of partnerships between utilities (both public and investor-owned) and entities such as local governments, non-profit organizations, and trade associations. For example, investor-owned utility programs targeting rebates for small business owners may partner with vendors, community-based organizations, and non-profit organizations. The Collaborative for High Performance Schools is another successful example of state government, utilities, and non-profit agencies working together for a common goal that includes energy efficiency as part of sustainable school design.

APPENDIX C: PIER COMMERCIAL SUCCESS STORIES THROUGH 2002

PIER recently completed an evaluation of the program's commercial successes through the end of 2002 and the benefits accruing to electric ratepayers as a result of those successes. A total of 20 commercial products were identified. The 20 commercial successes are shown in **Table C-1**. Benefits were quantified for 16 of the 20 products. Benefits accruing from applications of the successful products during the next five years are expected to total between $251 and $656 million. The total of the above encumbrances for all PIER programs between 1998 and 2002 is approximately $216 million. However, only about half of the total encumbrances have been expended by the Energy Commission to date. Thus, the PIER program will result in $2-5 in benefits for every dollar disbursed.

Table C-1
PIER RD&D Products Commercialized Through 2002

Residential and Commercial Buildings End Use Energy Efficiency:
Berkeley Lamp. A table lamp with two compact fluorescent bulbs designed to be operated independently to provide task lighting, indirect lighting, or a combination of the two. This lamp is designed to provide a high efficiency alternative to overhead lighting in offices and torchiere lighting in residences. Marketed by The Light Corporation.
Commercial Kitchen Ventilation. Guidelines for installation of hoods and make up air ducting in commercial kitchens to minimize the undesirable interactions between the flow of make up air and the flow of air contaminated by cooking vapors into the hood. Proper location and design of make up air ducts allows greatly reduced hood air flows, which reduces hood fan power and losses of conditioned air from the kitchen. Information disseminated by the PG&E Food Service Technology Center.
Particulate Emissions Measurement for Unhooded Restaurant Appliances. Protocol and techniques for measuring the emissions of particulate matter from restaurant appliances. A standard protocol is provided to determine the need for a hood for a specific appliance, and this protocol is recognized by the UL-Witness Test. The measurement technique is the basis for a test cell and testing service for appliances that is offered by the PG&E Food Service Technology Center.
Revised Residential Framing Factors. Update of California Title 24 Building Efficiency Code to update default framing factors for residential new construction. The framing factors (area of window and door frames divided by total wall area) could be used in energy calculations to determine the required level of wall insulation. Updated framing factors are higher, resulting in more required wall insulation and reduced energy use.
HVAC Duct Sealing Technique for Small Commercial Buildings. Update to Title 24 providing a standard for sealing HVAC ducts in small commercial buildings. The new requirements are based on the success of an aerosol spray technique for the internal surface of the ducts. AeroSeal offers the spray technique as a commercial service.

Allowable Placement of Roof/Ceiling Insulation in Nonresidential Buildings. Update to Title 24 requiring the placement of ceiling insulation for commercial buildings in contact with roof deck (interior or exterior) in most new buildings. Eliminates problems created by building renovations during which the integrity of the insulation is frequently compromised.
Requirements for Skylight Use in Low-Rise Residential and Commercial Buildings. Update to Title 24 requiring the use of skylights with timers or light sensor controls in new commercial buildings with 25,000 square feet of open area directly under a roof and with a ceiling height of 15 feet or more.
Goettl Comfortquest Gas Heat Pump. ***Vapor compression heat pump driven by a natural gas engine and offered in sizes between 15 and 30 tons. Offers a low electricity use option for areas where electricity supplies are extremely constrained.***
Real-Time Energy Management and Control Systems. Information monitoring and control system concept developed by Lawrence Berkeley National Laboratory to track the performance of large commercial HVAC equipment, diagnose troubles, and identify actions to increase operating efficiency. Concept was incorporated into commercial energy management and control software by Silicon Energy Corp. and by PowerNet Software.
Environmentally Preferred Advanced Generation:
Catalytica Xonon™ Catalytic Burner. Catalytic combustion burner for small gas turbines that is designed to reduce NOx emissions to 2 ppm. Several turbine manufacturers are integrating this burner into gas turbine systems.
Energy Systems Integration:
DG Interconnect Hardware. An inexpensive, Rule 21 compliant, solid state interconnection system to control grid-connected distributed generation systems. The interconnection hardware is offered commercially by EnCorp, Inc. as the Enpower™-GPC.
Real-Time Monitoring and Dynamic Rating System for Overhead Transmission Lines. Real-time monitoring and dynamic rating systems for electric transmission lines designed to replace the current overly conservative power limits. These limits are based on worst-case conditions that lead to overestimating the maximum thermal sag of the lines on hot days with little wind. A new system has been developed by PIER and applied by the CA ISO on the Path 15 segment connecting northern and southern California transmission systems.
Interconnection Standards for Small Distributed Generators. A common set of simplified procedures for reviewing and approving an application for a grid-connected distributed generator. Results to date (FOCUS-I) apply to cases where the DG unit is connected to the grid but does not supply power to the grid. A simplified review process has been developed that allows the DG applicant to bypass several stages of the previous review process if the applicant meets certain minimal requirements, resulting in a labor saving by both the applicant and utility reviewers.

Improved Substation Seismic Design. Laboratory simulation of interconnected electrical substation components under earthquake conditions. Demonstrated that certain types of interconnections (rigid or spring-loaded) could create stresses on insulators or forces on transformers and other equipment that led to more damage than would occur for isolated equipment. Has led to changes in substation design guidelines and in component selection that would reduce the damage from an earthquake.
Reduced Utility Building Seismic Vulnerability. Development of new building structural performance simulation tools and design tools for use by utilities located in earthquake zones. Designs were developed that ensure employee safety and reduce the likelihood of outages caused by building damage without overly conservative assumptions. A comparison of old and new approaches to retrofit of existing buildings has demonstrated that significant savings will accrue to PG&E as a result of less conservative approaches to retrofit of three common building types.
Renewable Energy Technologies:
NO_x Control in Biomass-Fueled Boilers with Natural Gas Cofiring. Adaptation to the California market of a technology developed by the Gas Technology Institute for gas cofiring of biomass-fueled boilers. Gas cofiring in the 5-15 percent gas range improves the power generation economics, reduces NO_x and CO emissions and allows operation of the plant at increased capacity compared to previous NO_x related limitations. This technology increases the plant turndown ratio, and improves the response of the electrical output to changing peak loads.
PowerGuard® - Solar Electric Systems for Flat Roofs. PowerLight's PowerGuard is a complete, pre-engineered system, easy to install and practically maintenance free. The patented, lightweight photovoltaic roofing assembly generates clean, reliable electricity while reducing the building's energy load and peak demand costs. Available in flat or angled tile arrays. Projected cumulative sales in California of 5 to 10 MW through 2006.
Energy-Related Environmental Research:
Low NO_x FIR Burner for Gas Boiler. A forced internal recirculation (FIR) burner for use in natural gas boilers, developed by DOE and the Gas Technology Institute, and now being incorporated into a boiler line by Detroit Stoker. The new burner uses several techniques, including premixed stoichiometric combustion, internal recirculation of combustion products, and staged combustion with enhanced combustion uniformity. The advancement reduces both NO_x emissions (to < 9 vppm) and CO emissions (to < 40 vppm) without sacrificing efficiency.
Industrial, Agriculture, and Water End Use Energy Efficiency:
Cast Metal Industry Electricity Consumption Study. A study of energy utilization for metal melting operations in California foundries. The study consisted of a Foundry Energy Survey to collect information and establish a profile of California metal melting operations through an examination of energy usage and cost savings strategies. Implementation of the study's technical recommendations will result in savings in melting energy usage. The study was distributed to virtually all foundries in California.

Poultry Rinse Recycling. A water recycling system for chilled rinse water used in poultry processing plants. Specifically, the new recycling system eliminates the need for chlorination of chilled water and replacement of chilled water daily by using ozone to kill bacteria and hollow membrane filtration to remove foreign matter.

Benefits were calculated by projecting sales or applications of the products for five years after their commercial introductions. Benefits per application of the product were estimated by evaluating the savings (energy cost, first cost, maintenance cost, labor costs, etc.) per year accruing to a typical user because he chose to use the PIER product rather than its most likely competitor. Any incremental costs required to use the PIER product rather than its competitor were subtracted from the cost savings. The resultant net savings per user were multiplied by the projected product sales for that year. Finally, the net present value of the savings for all products introduced during the first five years of product commercial use was calculated. The projected sales and the resultant benefits are both shown as ranges to reflect the uncertainties in the levels of projected use and to disguise any manufacturer proprietary sales forecasts. Because commercial applications of all the PIER product is just beginning, most sales estimates are still quite speculative at this time. Future evaluations will use actual sales data in place of projections to the extent possible. Benefits results are summarized in **Table C-2**.

PIER completed its fifth year of operation at the end of 2002. That is a very short amount of time to realize commercial successes from a RD&D program. A comparison of the length of time from project initiation to the first sale or commercial application of a product showed that the 20 projects evaluated took 3.2 years to succeed commercially. Thus, the typical product resulted from a PIER project that was initiated in 1998 or 1999. Contracts initiated later than 1999 simply have not had sufficient time for completion of RD&D and commercialization of products.

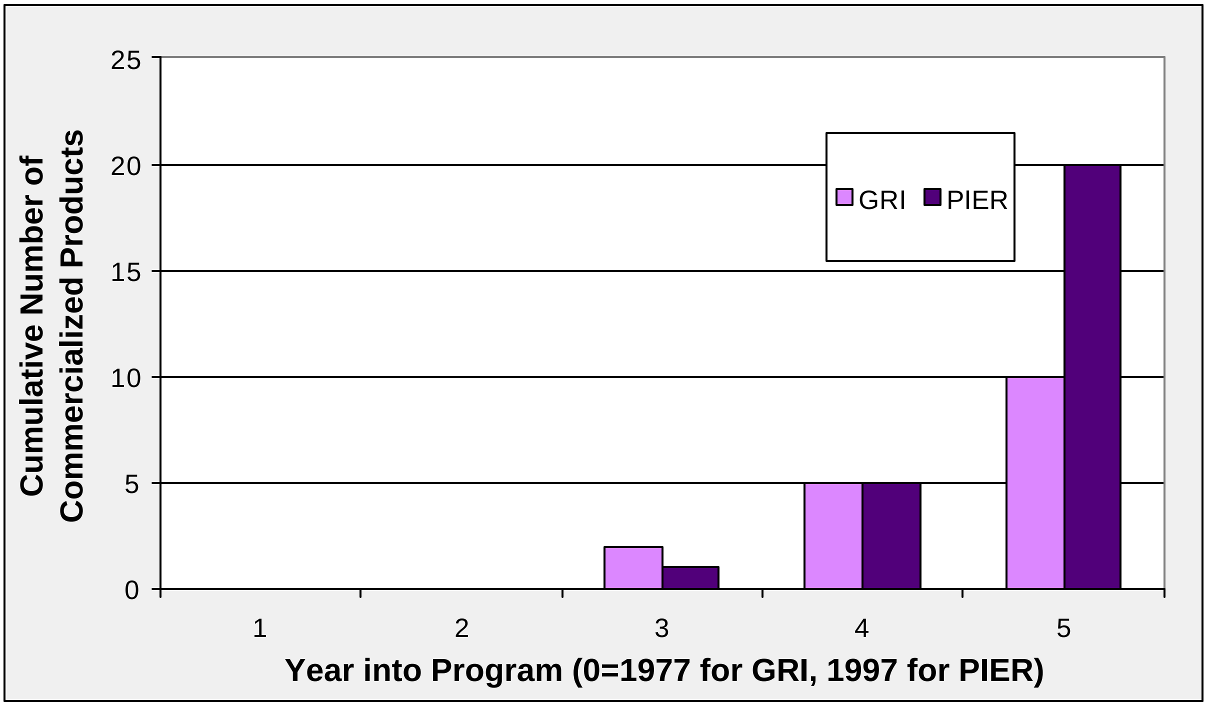
Table C-2
Benefits of PIER RD&D Products Commercialized Through 2002

PRODUCT NAME	Year of First Use	Sales or Applications in first five years	Range of Benefits ($ million)
Residential and Commercial Buildings End Use Energy Efficiency:			
Berkeley Lamp	2001	5,000 to 60,000	$2 to 23 million
Commercial Kitchen Ventilation	2007	2,000 to 10,000	$14 to 71 million
Particulate Emissions Measurement for Unhooded Restaurant Appliances	2001	Not tracked	< $1 million
Revised Residential Framing Factors—Title 24 Update (2005)	2005	100,000-200,000	$2 to 6 million
Duct Sealing Requirements for Small Commercial HVAC Systems—Title 24 Update (2005)	2005	50 to 175 million sq. ft.	$40 to 140 million
Allowable Placement of Roof/Ceiling Insulation in Nonresidential Buildings—Title 24 Update (2005)	2005	18 to 30 million sq. ft.	$67 to 112 million

PRODUCT NAME	Year of First Use	Sales or Applications in first five years	Range of Benefits ($ million)
Requirements for Skylight Use in Low-Rise Residential and Commercial Buildings—Title 24 Update (2005)	2005	80 to 175 million square feet	$70 to 150 million
Goettl Comfortquest Gas Heat Pump	2002	<100	< $1 million
Real-Time Energy Management and Control Systems	2002	Insufficient data	
Environmentally Preferred Advanced Generation:			
Catalytica Xonon? Burner	2002	50 to 250 MW	$5 to 25 million
Energy Systems Integration:			
DG Interconnect Hardware	2001	Insufficient data	
Real-Time Monitoring and Dynamic Rating System For Overhead Transmission Lines	2000	Insufficient data	
Interconnection Standards for Small Distributed Generators	2002	500 to 2,000 kW	$4 to 16 million
Improved Substation Seismic Design	2002	--	$1 to 2 million
Reduced Utility Building Seismic Vulnerability	2002	100 buildings	$15 to 20 million
Renewable Energy Technologies:			
NO_x Control in Biomass-Fueled Boilers with Natural Gas Cofiring	2002	2 to 7 boilers	$0.2 to 1 million
PowerGaurd-Solar Electric Systems for Flat Roofs	2001	5 to 10 MW	$30 to 80 million (Revenues)
Energy-Related Environmental Research:			
Low NO_x FIR Burner for Gas Boiler	2002-03	5 to 15	< $1 million
Industrial, Agriculture, and Water End Use Energy Efficiency:			
Cast Metal Industry Electricity Consumption Study	2001	5-50 percent CA market	$0.5 to 5 million
Poultry Rinse Water Recycling	2002	10 percent to 50 percent of market	$1 to 5 million

It is important to compare how PIER commercialization success compares to other R&D organizations with similar mandates. GRI demonstrated a very successful track record in producing commercially successful products and in creating benefits for the gas ratepayer over the years, producing over 500 commercially successful products from 1978 through 2001 and consistently documenting benefit-to-cost ratios well over one. GRI has published annual evaluations of the benefits of its commercially successful products since 1985. Data obtained from GTI, the GRI's successor, show that GRI claimed 5 commercially successful products at the end of its fifth year of operation. PIER, with its 20 commercially successful products at the end of its fifth year of operation (**Figure C-1**), compares quite favorably with the GRI's experience. The GRI's disbursements during its first five years was approximately $408 million in constant 2002 dollars, compared to $254 million in encumbrances for PIER, making PIER's productivity even more impressive.

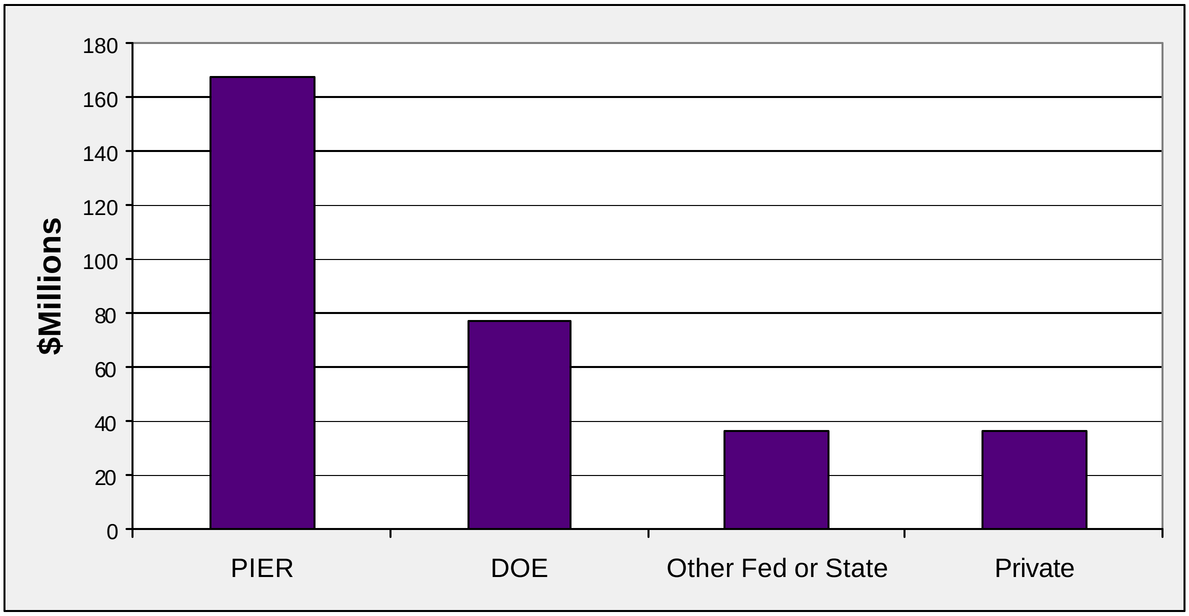
Figure C-1
PIER vs. GRI Early Commercialization Success



There are two other methods by which we can value success. First, many of our on-going activities are of sufficient significance that a number of our programs have significant financial collaborations from the federal government, other states, and the private sector. (**Figure C-2**) While the outcome of the programs remains to be seen, effective leveraging of our funding such as this provide for enhanced opportunity of success, while increasing funding coming to California-based organizations.

Second, we did not attempt to make a social valuation for our technologies. By this, we mean what additional value accrues to the state beyond market sales. While these are difficult and sometimes controversial to quantify, some quantitative examples are useful in this discussion. Most of PIER's successful end-use energy efficient technologies will provide additional social value for human health and avoided electricity use in their operational lifetimes. The reduction of energy needed (electricity and natural gas) will lead to an avoidance of energy usage and harmful pollutants arising from energy use. Socially beneficial costs can be developed for these technologies. Further, our other programs in renewables, Environmentally Preferred Advanced Generation, and environmental are also developing technologies - all of which, have beneficial social values.

Figure C-2
R&D Collaborations



Finally, a number of our Energy Systems Integration technologies allow for more efficient operation of the electricity grid which leads to - among other things, fewer blackouts. This outcome by itself has huge beneficial social value. The difficulty is to properly value these societal benefits. Other externalities associated with the electricity system must also be properly valued when considering the overall benefits to product life-cycles.

LIST OF ACRONYMS

Air condition (AC)
Air Quality Management Districts (AQMDs)
Air Resources Board (ARB)
Billion therms (BTh)
California Integrated Waste Management Board (CIWMB)
California Department of Forestry (CDF)
California Independent System Operator (CA ISO)
California Public Utilities Commission (CPUC)
Carbon dioxide (CO_2)
compact fluorescent lamps (CFLs)
Consumer Power and Financing Authority (CPA)
cooling degree day (CDD)
Critical Peak Pricing – Fixed (CPP-F)
Critical Peak Pricing - Variable (CPP-V)
Critical Peak Pricing (CPP)
Database of State Incentives for Renewable Energy (DSIRE)
Demand-Side Management (DSM)
Department of the Interior (DOI)
Distributed Energy Resources (DER)
Distributed Generation (DG)
Electric Power Research Institute (EPRI)
Electric Service Providers/Community Choice Aggregators (ESP/CCAs)
Emerging Technologies Coordinating Council (ETCC)
Federal Energy Regulatory Commission (FERC)
Gas Research Institute (GRI)
Gas Technology Institute (GTI)
Gigawatt hours (GWh)
Greenhouse Gas (GHG)
Heating, Ventilation and Air Conditioning (HVAC) Systems
Interim Standard Offer 4 (ISO4)
International Energy Fund (IEF)
Investor-owned utilities (IOUs)
Kilovolt (kV)
kilowatt (kW)
Kilowatt hour (kWh)
Lawrence Berkeley National Laboratory (LBNL)
liquefied natural gas (LNG)
Los Angeles Department of Water and Power (LADWP)
market transformation" (MT)
Megawatt (MW)
Megawatt hours (MWh)
Million therms (MTh)
National Environmental Policy Act (NEPA)

National Renewable Energy Laboratory (NREL)
Nitrogen Oxides (NO_x)
Office of Ratepayer Advocates (ORA),
Pacific Gas & Electric (PG&E)
photovoltaic (PV)
Preliminary Renewable Resource Assessment (PRRA)
Public Goods Charge (PGC)
Public Interest Energy Research (PIER)
Public Utility Regulatory Policies Act (PURPA)
qualifying facilities (QF)
Quarterly Fuels Energy Report (QFER)
Regional Energy Policy Advisory Council (REPAC).
Renewable Resource Trust Fund (RRTF)
Renewables Portfolio Standard (RPS)
Request for Proposals (RFP),
Research Development and Demonstration (RD&D)
Sacramento Municipal Utility District (SMUD)
San Diego Gas& Electric (SDG&E)
San Diego Regional Energy Office (SDREO)
Seasonal Energy Efficiency Rating (SEER)
Silicon Valley Power (SVP),
Southern California Edison (SCE)
Sulfur dioxide (SO_2)
Time-of-Use (TOU)
Transmission and Distribution (T&D)
U.S. Department of Energy (DOE)
Western Electricity Coordinating Council (WECC)

ENDNOTES

[1] This report does not specifically evaluate public interest strategies that address transportation issues. Transportation strategies are instead addressed in the ***Transportation Fuels, Technologies and Infrastructure Report***.

[2] Severin Borenstein. "The Trouble with Electricity Markets (and some solutions)." January, 2001 POWER PWP-081.

[3] Hoff, K. and R.W. Marlow. 2002. *Impacts of Vehicle Road Traffic on Desert Tortoise Populations with Consideration of Conservation of Tortoise Habitat in Southern Nevada*. Chelonian Conservation and Biology. 4(2):449-456.

[4] Fenn, M.E., J.S. Baron, E.B. Allen, H.M. Rueth, K.R. Nydick, L. Geiser, W.D. Bowman, J.O. Sickman, T. Meixner, D.W. Johnson, and P. Neilich. 2003a. *Ecological Effects of Nitrogen Deposition in the Western United States*. BioScience. 53(4): 404-420.
Fenn, M.E., R. Haeuber, G.S. Tonnesen, J.S. Baron, S. Grossman-Clarke, D. Hope, D.A. Jaffee, S. Copeland, L. Geiser, H.M. Rueth, and J.O. Sickman. *Nitrogen Emissions, Deposition, and Monitoring in the Western United States*. Biosicence. 53(4): 391-403.

[5] Total natural gas savings would be less if incremental DSM were implemented first, as called for in this policy report. This occurs because overall demand would be lower – hence there would be less generation to displace – and DSM would displace the most inefficient natural gas power plants first. This case is analyzed in the *Electricity and Natural Gas Assessment Report*.

[6] For details see *California Energy Demand 2003-2013 Forecast*. February 11, 2003. Staff draft report, 100-03-02SD and subsequent revisions.

[7] Rufo, M. and F. Coito. 2002. *California's Secret Energy Surplus: The Potential for Energy Efficiency*. Final report prepared by Xenergy Inc. for The Energy Foundation and The Hewlett Foundation.

[8] The Energy Commission uses the UCLA Anderson School of Business economic forecasts plus additional data from Global Insight as the basis for energy demand forecasts.

[9] Brown, R.E. and J.G. Koomey. 2002. "Electricity Use in California: Past Trends and Present Usage Patterns." Review draft submitted to *Energy Policy*.

[10] Natural gas consumption in California is divided into two approximately equal categories: "direct" and "indirect" consumption. Direct consumption refers to natural gas that is burned at the end-use level, such as for heating a home; indirect consumption refers to natural gas that is burned to produce electricity, and in so doing indirectly serves customers' end-use needs

[11] The percentages shown here are for direct end-uses only and do not include natural gas for generating facilities.

[12] California Energy Demand 2000-2010. Staff Report. P200-00-002.

[13] *California Statewide Commercial Sector Natural Gas Energy Efficiency Potential Study. Draft Report*. January 14, 2003. Prepared by Xenergy Inc. for Chris Ann Dickerson, Project Manager, PG&E.

[14] A detailed history of the public benefit programs is provided in: Office of Ratepayer Advocates. 2002. *The Public Purpose Energy Efficiency Surcharge: Trends and Patterns in the Costs and Benefits of Utility Administered Energy Efficiency Programs*. Public Utilities Commission.

[15] Reporting requirements for natural gas expenditures and savings have varied over the years rendering these numbers less reliable than electricity.. The Energy Commission is attempting to identify sources to clarify the data.
[16] Office of Ratepayer Advocates. 2002, p. 1-1.
[17] *CPUC 2001 Energy Efficiency and Conservation Programs*. December 2001. Report to the Legislature. Prepared by the Energy Division, p.4.
[18] Smith, D. 1995. *Savings and Costs of Statewide Efficiency Standards*. Energy Commission staff draft report. December 20.
[19] For a multi-state review of "reliability-focused energy efficiency programs" implemented in the summer of 2001, see Kushler, M., E. Vine, and D. York. 2002. *Energy Efficiency and Electric System Reliability: A Look at Reliability-Focused Energy Efficiency Programs Used to Address the Electricity Crisis of 2001*. Washington D.C.: American Association for an Energy-Efficient Economy.
[20] For a complete listing see Appendix A in: Global Energy Partners, LLC. 2003. *California Summary Study of 2001 Energy Efficiency Programs*. Final Report. Submitted to Southern California Edison and The California Measurement Advisory Council.
[21] The CA ISO covers 84 percent of the state.
[22] Global Energy Partners, LLC. 2003. These figures reflect the best estimation of the Summary Study authors, based on comparisons to established benchmarks, professional judgment, and adjustments to reported savings based on uncertainty
[23] Programs outside the scope of coverage included demand responsiveness programs, load-shifting programs, low-income programs, renewable programs, smaller municipal utilities, and code changes. The 20/20 and *Flex Your Power* programs were included.
[24] Kushler, *Using Energy Efficiency to Help Address System Reliability*.
[25] See Lutzenhiser, L., S. Bender and M. Gossard. 2002. "Crisis in Paradise: Understanding the Household Conservation Response to California's 2001 Energy Crisis," in *Proceedings of the 2002 ACEEE Summer Study on Energy Efficiency in Buildings*. Washington D.C.: American Council for an Energy Efficient-Economy; Lutzenhiser, L., et. al. 2003. *Household Energy Use as a Result of the California Energy Crisis*. Draft report in progress for the California Energy Commission; and Goldman, C., J. Eto, and G. Barbose. May 2002. *California Customer Load Reductions during the Electricity Crisis: Did they Help to Keep the Lights On?* LBNL-49733. Lawrence Berkeley National Laboratory.
[26] Produced by Xenergy for The Energy Foundation and The Hewlett Foundation, 2002
[27] *California Statewide Commercial Sector Natural Gas Energy Efficiency Potential Study*. 2003. Draft Report. 2 vols. Study ID #SW039A. Prepared for Pacific Gas and Electric Company. Oakland: Xenergy.; *California State Residential Sector Energy Efficiency Potential Study*. 2003. Final Report. Study ID #SW063. Prepared for Pacific Gas and Electric Company , Oakland: KEMA-XENERGY; *California Statewide Commercial Sector Energy Efficiency Potential Study*. 2002. Final Report. 2 vols. Study ID #SW039A. Prepared for Pacific Gas & Electric Company. Oakland: Xenergy. These studies used Energy Commission data as the foundation of their analyses, so the results are largely consistent with the assumptions embedded in Energy Commission staff's baseline forecast and DSM scenario analysis. All of these studies were funded by the CPUC with public goods funding.
[28] Messenger, M. September 3, 2003. *Discussion of Proposed Energy Savings Goals for Energy Efficiency Programs in California*. Working draft courtesy of author.

[29] See Lutzenhiser (2003) and Goldman (2002) cited above.
[30] Controlling for the effects of other factors, including weather, dwelling size, income, appliances, and household composition.
[31] Kushler, M. and P.Witte. 2000. *A Review and Early Assessment of Public Benefit Policies Under Electric Restructuring, Volume 2: A Summary of Key Features, Stakeholder Reactions, and Lessons Learned to Date.* Washington, D.C.: American Council for an Energy-Efficient Economy, p.12.
[32] Kushler, M. and P.Witte. 2000, p. iv.
[33] Keynote address, June 10, 2003, *Energy Efficiency as a Resource Conference*. Sponsored by the American Council for an Energy Efficient-Economy, Berkeley, CA.
[34] The three agencies are the Consumer Power and Conservation Financing Authority, the California Energy Commission, and the CPUC.
[35] The New York Independent System Operator has funded studies of demand response programs impacting prices in 2002 and 2003, which find beneficial impacts by reducing market prices.
[36] Borenstein, Severin, Dynamic Pricing, Advanced Metering and Demand Response in Electricity Markets, The Energy Foundation, October 2002, pp. 10-11.
[37] ***Wolak, Frank, CA ISO Market Surveillance Committee Report***, September, 1999, p. 22
[38] CPUC, R.02-06-001, Order Instituting Rulemaking on policies and practices for advanced metering, demand response, and dynamic pricing.
[39] The $35 million authorized by AB 29X for meters, plus additional expenditures by utilities, has resulted in 25,000 customers having an RTP metering system. It consists of an interval recording meter, an electronic communication channel to read the meter, and an internet-based website where each customer can obtain their own usage data from the day before. Further, by D.01-09-XXX, all >200 kW not then on time-of-use tariffs were shifted to a TOU tariff once their metering system was installed.
[40] About 10 percent of the electric utility customers in the nation now have advanced metering systems, and the regulatory commissions in several western states are in various stages of deciding whether or not to make this investment.
[41] For a review of these findings, see Lutzenheiser, L., et al. 2003. *Time for Time- of- Use: A Review of Residential Dynamic Pricing Issues.* Work in progress for the California Energy Commission.
[42] Report of Working Group 3 to Working Group 1, CPUC Rulemaking R.02-06-001, Final Version 5, December 10, 2002, page 18.
[43] **Christenson Associates, Electricity Customer Price Responsiveness – *Literature Review of Customer Demand Modeling And Price Elasticities*** (consultant report to the CEC September 29, 2000)
[44] See California Energy Commission, CPUC, California Power Authority (May 8, 2003), ***Energy Action Plan***. Available online at http://www.energy.ca.gov/2003_energy_action_plan/. Accessed June 19, 2003.
[45] Staff divided the WECC members into three categories: 1) California, adjacent states (Oregon, Nevada, Arizona), and Washington; 2) outer tier states (i.e., Montana, Idaho, Wyoming, Utah, Colorado, New Mexico; and 3) international WECC members. This division of WECC members is intended to match the transmission and RPS rule-making

issues associated with transporting electricity from adjacent, non-adjacent, and international WECC members.

[46] For a detailed discussion of installed capacity, proposed projects, technical potential, estimated energy requirements to meet California's RPS, and a plausible scenario see the staff draft of the ***Preliminary Renewable Resource Assessment*** (Pub. No. 100-03-009P). Available online at www.energy.ca.gov/energypolicy/documents/.

[47] See California Energy Commission, CPUC, California Power Authority (May 8, 2003), ***Energy Action Plan***. Available online at http://www.energy.ca.gov/2003_energy_action_plan/. Accessed June 19, 2003.

[48] See Database of State Incentives for Renewable Energy (DSIRE): Incentives by State. Available online at www.dsireusa.org. Accessed 4/18/03.

[49] See Database of State Incentives for Renewable Energy (DSIRE): Incentives by State. Available online at www.dsireusa.org. Accessed 6/17/03.

[50] See Database of State Incentives for Renewable Energy (DSIRE): Incentives by State. Available online at www.dsireusa.org. Accessed 6/17/03.

[51] See Database of State Incentives for Renewable Energy (DSIRE): Incentives by State. Available online at www.dsireusa.org. Accessed 6/17/03.

[52] These data are derived from the Energy Commission's "1983-2001 California Electricity Generation." Available online at www.energy.ca.gov/electricity/. These data include electricity from geothermal, organic waste, wind, solar and the portion of hydroelectricity generated by systems that are 30 MW or smaller.

[53] California Energy Commission, April 2003, "Amount (MW) of Grid Connected Solar Photovoltaics (PV) in California, 1981 to Present." Available online at http://www.energy.ca.gov/renewables/emerging_renewables.html . Accessed June 14, 2003.

[54] Data source: ***Energy Information Administration, Electric Power Annual 2000, Volume 1 – Net Generation of Industry by state and resource for year 1999,*** as cited in Nielsen et al, 2002, p. 16.

[55] Estimates for California's renewable technical potential vary, sometimes greatly, among studies. The reasons for these variations may include the different time frames in which the studies were conducted, the filtering of data using differing criteria, and in the case of solar, how photovoltaic and central station are counted or characterized.

[56] California Energy Commission, 1983-2002 California Electricity Generation (J-11 table). Available online at http://www.energy.ca.gov/electricity/index.html#generation.

[57] This estimate is for urban grid-tied applications in commercial, residential and parking lot projects. Regional Economic Research, Inc. June 2002. ***California Renewable Energy Program Technical Potential of Renewable Resource Technologies 2001 Update. Final Report – Work Authorization no. 21***. Vancouver, WA: Regional Economic Research, Inc.

[58] ***Assessing Rooftop Solar-Electric Distributed Energy Resources for the Local Government Commission.*** Cristy Herig, National Renewable Energy Laboratory, October 2000.

[59] These cost data were collected from a variety of sources and are not based on project specific data. The data in the table are reflections of historical cost trends and not precise annual historical data. Actual project costs can vary substantially based on location, technology, permitting fees and operating costs. Conversion of wave power to energy may become cost competitive in the future; however, the economics of the technology will need

to be tested and verified on a full-scale operation. An assessment of several wave power systems in 1999 in the United Kingdom showed that the average cost of electricity generation was 7.5 cents per kWh. While these projected costs look encouraging, further analysis is required. Sources used to compile cost trend data are as follows: California Energy Commission, ***Comparative Cost of California Central Station Electricity Generation Technologies***, Integrated Energy Policy Report Proceeding Docket 02-IEP-01, June 5, 2003; NREL Energy Analysis Office, "Renewable Energy Cost Trends," available online at www.nrel.gov/analysis/docs/cost_curves_2002.ppt, Accessed June 19, 2003; EPRI, ***Renewable Energy Technical Assessment, Guide-TAG-RE 2002.***

[60] The Department of Water Resources (DWR) has partnered with Pacific Gas and Electric to provide credit support for a one-year period. The following Confirmation letters from PG&E's interim procurement are available online at http://wwwcers.water.ca.gov/contracts.html: 1) December 23, 2002, *Confirmation Letter for*: *CPN/PG&E/DWR – Unit-Firm Renewable Product Geysers Unit 13 (GEYS13 7 Unit 13*); 2) December 23, 2002. *Confirmation Letter for: CPN/ PG&E/DWR – Unit-Firm Renewable Product* Geysers Unit 20 (GEYS20 7 Unit20; 3) December 20, 2002 NDC Consulting Engineers, Inc. Confirmation Letter – Unit-Firm Renewable Product; 4) December 20, 2002 Wheelabrator Shasta Energy Company, Inc. Confirmation Letter – Unit-Firm Renewable Product.

[61] Publicly available data from the following solicitations were reviewed: the Energy Commission's New Renewable Resources Account database, California Power Authority Letters of Intent, Southern California Public Power Authority Request for Proposals (RFP), Bonneville Power Authority Transmission Information database, the Sierra Pacific RFP, and Foresight Energy's ongoing review of press releases and other data sources. Data for proposed projects within California rely on publicly available information from the IOU Interim Procurements. Information from the NCPA solicitation was not available in time to be included in this analysis. Only 20 percent of the proposed projects reviewed for this study responding to auctions and RFPs were judged to be redundant. Redundant projects were excluded from the analysis. This suggests that a significant number of new proposed projects are entering the queue each year in California and the WECC states.

[62] To develop these increments, Energy Commission staff used the following calculations. First, staff added one percentage point to the 2001 (preliminary) baseline percentage of retail sales (GWh) provided by renewable energy. For example, for the PG&E service area, the baseline percentage of electricity provided by renewable energy was 9.95 percent (7,532 GWh of 75,681 GWh in retail sales for 2001). The total amount of electricity from renewable energy estimated for delivery to PG&E customers in 2003 is 10.95 percent (9.95 percent plus 1 percent). For 2004, the value is 11.95 percent. This trend is continued until 20 percent is reached. Second, these values were adjusted for information announced by utilities regarding interim procurement results for 2003. Third, the adjusted values were multiplied by the forecasted retail sales from 2003-2017 to calculate the total amount of electricity to be generated from renewable energy to achieve the RPS goal. For further information, see the ***Preliminary Renewable Resource Assessment***. Available online at http://www.energy.ca.gov/energypolicy/documents/index.html. Accessed June 25, 2003.

[63] See Electric Power Research Institute, *California Renewable Technology Market and Benefits Assessment*, November 2001. Prepared under contract to the Energy Commission.

See also, Environment California Research and Policy Center, *Renewable Energy and Jobs: Employment Impacts of Developing Markets for Renewables in California*, July 2003. Note: the technology mix assumed by Environment California was 35 percent wind, 50 percent geothermal, and 15 percent biomass.

[64] Imperial Irrigation District resources are included in SCE's RPS planning process.

[65] Imperial Irrigation District resources are included in SCE's RPS planning process.

[66] The retail sales estimate and other data used to develop the RPS information have been revised since the scenarios were modeled. For example, the MarketSym ™ scenario for achieving RPS by 2010 assumes an average addition of 600 MW per year of renewable energy resources from 2004 through 2013 for IOUs only. Because the load forecast has been revised downward, the 600 MW number now appears to be high. Staff's current estimate for the accelerated scenario (using a 50percent capacity factor) is the addition of about 800 MW from 2004-2010 statewide (5,600 MW). For RPS, the MarketSym ™ scenario assumes an average addition of 400 MW per year from 2004-2013 of renewable energy resources for IOUs only. Current estimates for additions to meet RPS (assuming a 50percent capacity factor) are about 280 MW for IOUs only and 600 MW per year statewide from 2004-2017.

[67] Mark Bolinger, Ryan Wiser, and William Golove, August 2003, ***Accounting for Fuel Price Risk: Using Forward Natural Gas Prices Instead of Gas Price Forecasts to Compare Renewable to Natural Gas-Fired Generation***. Berkeley, CA: Ernest Orlando Lawrence Berkeley National Laboratory, Environmental Energy Technologies Division (LBNL-53587).

[68] California Energy Commission, 2003, *Staff Draft Energy Infrastructure Assessmen*t, (Pub No. 100-03-007F), p. 19.

[69] Based on the following assumptions: 20 lbs CO2/gallon.20 miles/gallon, 20,000 miles/vehicle-year.

[70] California Energy Commission, 2003, "Developing Methods to Reduce Bird Fatalities in the Altamont Pass Wind Resource Area Project Description (Contract # 500-01-019), ***Public Interest Energy Research Annual Report 2002, Appendix A: PIER Program Project Summaries***, p. 135.

[71] K. Sinclair, 2001, ***Status of Avian Research at the National Renewable Energy Laboratory***, NREL: Golden, CO. Available online at http://www.nrel.gov/docs/fy01osti/30546.pdf. Accessed June 13, 2003.

[72] Bonneville Power Administration, February 22, 2001, *Request For Wind Project Proposals*, p. 10. Available online at http://www.bpa.gov/power/pgc/wind/Wind_RFP_Final.pdf. Accessed June 11, 2003.

[73] EPRI, 2002, *Renewable Energy Technical Assessment, Guide-TAG-RE 2002*.p. 6-24.

[74] Union of Concerned Scientists, *Clean Energy Backgrounder: Environmental Impacts of Renewable Energy Technologies*, adapted from material in the UCS book *Cool Energy: Renewable Solutions to Environmental Problems*, by Michael Brower (MIT Press, 1992). See http://www.ucsusa.org/clean_energy/renewable_energy/. Last updated 10/26/2002. Accessed June 13, 2003.

[75] EPRI, 2002, *Renewable Energy Technical Assessment, Guide-TAG-RE 2002*, p. 6-24.

[76] For example, see California Energy Commission, California Distributed Energy Resource Guide: DER Equipment: Stirling Engines," Available online at http://www.energy.ca.gov/distgen/equipment/. Accessed June 14, 2003.

[77] Public Utilities Code, Section 383.5(d)(6)(C), as amended by SB 1038.
[78] EPRI, 2002, ***Renewable Energy Technical Assessment, Guide-TAG-RE 2002,*** p. 4-75.
[79] EPRI, 2002, ***Renewable Energy Technical Assessment, Guide-TAG-RE 2002,*** p. 7-18
[80] U.S. Department of Labor, Occupational Safety and Health Administration, "Safety and Health Topics: Cadmium." Revised December 20, 2002. Available online at http://www.osha.gov/SLTC/cadmium/index.html. Accessed June 14, 2003.
[81] U.S. Agency for Toxic Substances and Disease Registry, June 1999, "ToxFaqs™ for Lead," CAS# 7439-92-1. Available online at http://www.atsdr.cdc.gov/tfacts13.html. Accessed June 14, 2003.
[82] **Vasilis Fthenakis and Ken Zweibel, 2003, *CdTe PV: Real and Perceived EHS Risks,* Prepared for the NCPV and Solar Program Review Meeting 2003 . Available online at http://www.nrel.gov/cdte/pdfs/. Accessed June 14, 2003. See also EPRI, 2002, p. 5-28.**
[83] In defining "eligible renewable energy resource" for California's RPS SB 1078 (Section 399.12) refers to the definition of "in-state renewable electricity generation technology" in Section 383.5 of SB 1038, subject to related requirements of SB 1078. SB 1038, Section 383.5(b)(1)(A) contains a list of renewable energy generation technologies that are eligible for support through the Energy Commission's Renewable Energy Program, provided that related requirements in SB 1038 and guidelines for its implementation are met. The list contains the following technologies: biomass, solar thermal, photovoltaic, wind, geothermal, fuel cells using renewable fuels, small hydroelectric generation of 30 MW or less, digester gas, municipal solid waste conversion, landfill gas, ocean wave, ocean thermal, or tidal current, and any additions or enhancements to the facility using that technology.
[84] California Energy Commission, June 24, 2002, "Ocean Energy," http://www.energy.ca.gov/development/oceanenergy/ Accessed June 14, 2003.
[85] EPRI, 2002, ***Renewable Energy Technical Assessment, Guide-TAG-RE 2002,*** p. 8-55, 56.
[86] See California Energy Commission, May 2003, ***RPS: Decision on Phase I Implementation Issues, Final Committee Report***. Available at http://www.energy.ca.gov/portfolio/documents/. Accessed June 14, 2003.
[87] See *Hydropower: Filing a Hydropower License Application with the Commission*, particularly the environmental reporting requirements described in Title 18, Section 4.41, available online at http://www.ferc.gov/hydro/docs/license_application.htm. Accessed June 14, 2003. See U.S. Fish and Wildlife Service, "National Fish Passage Program: Reconnecting Aquatic Species to Historical Habitats," available online at http://fisheries.fws.gov/FWSMA/fishpassage. Accessed June 14, 2003. See also, Low Impact Hydropower Institute, Low Impact Hydropower Certification Criteria, Summary of Goals and Standards. Available at http://www.lowimpacthydro.org/. Accessed June 14, 2003.
[88] Incremental hydro is the addition of generation at a hydropower facility that is already generating power. The incremental power may come from water not already in use for generation purposes (e.g., water in a fish passage system).
[89] California Energy Commission, June 2002, *DGn Strategic Plan*, (P700-02-002), p. 31.
[90] U.S. DOE, September 2000, *Strategic Plan for Distributed Energy Resources*, p. 2. Available online at http://www.eere.energy.gov/der/pdfs/derplanfinal.pdf. Accessed June 26, 2003.
[91] These include Energy Commission, June 2002, DGn Strategic Plan, P700-02-002; Energy Commission, Rulemaking Pertaining to Data Collection for Qualified Departing Load CRS

Exemptions Docket #03-CRS-01; Rule 21 Working Group (interconnection rules for DGn); CPUC Rulemaking 02-01-011, in which D. 03-04-030 was adopted (April 3, 2003) regarding cost responsibility surcharge mechanisms for customer generation departing load.

[92] Comments provided by PG&E, Energy Commission IEPR Committee hearing held August 28, 2003.

[93] SB 1194 and SB 1038 authorize collection of 51.5 percent of $ 135 million/year for SEP payments from 2002-2011 in support of RPS (about $695 million). The actual amount available for SEP payments may be higher, due to interest earned on the unexpended portion of these funds, rollover funds from the SB 90 programs, and balance transfers from other programs within the Renewable Energy Program.

[94] ***Governor's Budget 2003-2004***, http://www.documents.dgs.ca.gov/osp/ GovernorsBudget04/pdf/res.pdf. Accessed June 25, 2003.

[95] For information on electricity storage technologies see EPRI, ***Renewable Energy Technical Assessment Guide-TAG-RE 2002***, chapter 9.

[96] For information regarding peak energy demand in California, see California ISO, "Today's Outlook," updated every 10 minutes. Available online at http://www.caiso.com/outlook.html. Accessed June 17, 2003.

[97] EPRI, ***Renewable Energy Technical Assessment Guide-TAG-RE 2002***.

[98] California Energy Commission, 2003, "Project 4.3 Energy Storage for Renewable Generation (Contract # 500-01042)." ***Public Interest Energy Research Annual Report 2002, Appendix A PIER Program Project Summaries***,

[99] California Energy Commission, 2003, "Project 4.3 Energy Storage for Renewable Generation (Contract # 500-01042)." ***Public Interest Energy Research Annual Report 2002, Appendix A PIER Program Project Summaries***, p. 78. Project Amount: $318,728. Match Funding: $82,837.

[100] CA ISO, April 11, 2003, ***2003 Summer Assessment***. Available online at http://www.caiso.com/docs/2003/04/25/200304251431521744.pdf. Accessed June 20, 2003.

[101] Verbal comments provided by Steven Kelly, Independent Energy Producers Association, at the Energy Commission's IEPR Committee Hearing held August 28, 2003.

[102] http://www.ladwp.com/whatnew/dwpnews/020303.htm.

[103] http://www.smud.org/res_plan/append/tech.html#smudres

[104] http://www.rosevilleelectric.org/newsletter/ed1_may03.htm

[105] http://www.anaheim.net/utilities/news/2002_greenpower.htm

[106] http://www.siliconvalleypower.com/Residential/HometownAdvantage/CleanPower.html

[107] http://www.mid.org/board_of_directors/brd_reports_2002/july_2_02.htm

[108] Correspondence from Jerry Jordan, Executive Director California Municipal Utilities Association to William J. Keese, Chairman, California Energy Commission, July 15, 2003.

[109] See California Energy Commission, CPUC, California Power Authority (May 8, 2003), ***Energy Action Plan***. Available online at http://www.energy.ca.gov/2003_energy_action_plan/. Accessed June 19, 2003.

[110] ***CPUC Working Group Report on Public Interest RD&D*** (September, 1996)

[111] Note that the terms "public interest" and "public benefits" are not interchangeable. "Public interest" RD&D is RD&D that provides for "public benefits."

[112] For tangible products (hardware, software), "commercialized" means that the product is commercially available, economically viable without subsidies, and has been sold in its

intended market. For the less tangible reports and other information products, "commercialized" means that the product has been used in a commercial enterprise or for a regulatory application and has generated demonstrable economic benefits to the users or the public.

[113] (AB) 1002, R. Wright. Natural Gas: Consumption Charge

[114] **California Energy Commission's Annual Energy Company Survey** (2003); Energy Technology Export Program; results obtained July 2003.

[115] *Beyond Kyoto: Toward a Technology Greenhouse Strategy* [on-line article by James A. Edmonds] Accessed in May 2003 on **Consequences: The Nature and Implications of Environmental Change**; http://www.gcrio.org/CONSEQUENCES/vol5no1/beyond.html; Internet.

[116] United Nations Framework Convention on Climate Change (UNFCCC); http://unfccc.int/; (Accessed April- June 2003); Internet. The 39 developed nations are referred to as "Annex 1" or "Annex B" nations in the Kyoto Protocol. The developing countries are referred to as "non-Annex".

[117] ***International Emissions Trading: A Primer*;** [On-line article **by Raymond Kopp and Michael Toman]** (Accessed May 2003) **Weathervane: A Digital Forum for Global Climate Change Policy**; http://www.weathervane.rff.org/features/feature049.html; Internet.

[118] **CDM Watch: Monitoring the Clean Development Mechanism of the Kyoto Protocol** [Internet organization] (Accessed June 2003); http://www.cdmwatch.org/.

[119] These credits are called Credit Reduction Units (CRUs) in the Protocol.

[120] World Bank Prototype Carbon Fund; http://prototypecarbonfund.org/router.cfm?Page=Home; (Accessed May 2003); Internet.

[121] To be fair, we should point out that the resource acquisition approach favored technology because its effects could be readily measured. This allowed energy efficiency to be considered a resource equivalent to supply side resources. To counter the politically-damaging image of conservation as "sacrifice" in the Carter era, attempts were made to redefine energy conservation as "efficient use of resources," that is, a way to get an equivalent level of service (no sacrifice) with less energy use. In the resource acquisition approach, behavioral study was limited to possible degradation of performance of energy efficiency technology (e.g., when persons were not willing to adopt the technology, or when they did not operate or maintain it properly).

[122] Although MT was seen by some critics as, itself, being an "exit strategy" from the entire policy commitment to energy efficiency, others saw opportunities to encourage the introduction of new efficiency technologies and to allow consumer preferences for cleaner and greener energy to be expressed in the marketplace. In any event, it's fair to observe that MT never really had a fighting chance in California, since it developed in the shadow of the radical restructuring of energy supply. However, because it was incubated under different regulatory and market conditions, MT is still being aggressively pursued elsewhere.

[123] In reference to the scientific underpinnings of these perspectives and solutions, Epoch 1 was dominated by natural science and engineering frameworks, Epoch 2 by economic models, and Epoch 3 by emerging interdisciplinary perspectives. In terms of the energy system's conceptions of consumers and consumer behavior, there has been a related shift in thinking from "device-centered/non-existent consumer," to "rational actor/device-invisible," to "actor-network" or "people-and-devices" understandings of the systems of interest.

[124] Counties and climate zones do not exactly overlap, so there is some extra approximation error in the analysis.
[125] Average daily kWh was modeled as a linear function of the of daily cooling and heating degree days with allowance for differences in the post 9/1/2000 period from the overall sample reaction. This was estimated as a full random parameters model using the REML method. See Woods (2002) for details.
[126] The actual hypothesis test is whether the reaction is different in the crisis than the *overall period*.
[127] This is similar to the results of a survey conducted by E Source (2002).
[128] The survey data have been weighted to match the demographic characteristics for each utility and thus reflect the conservation actions one might expect for all households in the five utility service areas.
[129] It is possible for respondents to report actions in one or more category, e.g., 'Not Using AC Behavior' and 'Other Heat/Cooling Behavior' codes would be assigned to a household reporting "not using the AC" and "night venting". When these particular categories of behavior are combined and only one unique behavior is counted , 44.7percent of households were found to have made at least one change in cooling/heating behavior.
[130] *Flex Your Power* did offer several ads featuring fans and breezes, but not taking the AC issue on directly.
[131] The CA ISO covers 84 percent of the state.
[132] The adjustment takes the form of allowing the respondents second year statement of first year action to be counted as performing the action the first year.
[133] This is 5percent lower bound on the confidence interval of our estimates. Details on the computation methods and confidence interval may be found in Woods (2003).
[134] Even relatively minor decreases in the chances of reporting a behavior, like we have in lighting can result in a rather large increases in our beliefs about the incidence of some kinds of behavior. If people tell us about a behavior only half the time, we must roughly double our estimates of their performing that action. If they tell us a third of the time we must triple our estimate. The actual calculations are significantly more complicated (see Woods 2003 for details).
[135] Closed response surveys can benefit from a "lie" question, asking about something a very small part of the population will agree to. This question can then be used to estimate the chances of a respondent claiming to perform a behavior they don't actually practice. Correcting for the overstatement of closed-response surveys, and the understatement of open-response surveys, is one of the more important analysis steps in understanding what our population is trying to tell us.
[136] The figures shown in **Table A-7** represent fractions of respondents performing a conservation action in each year. They make no representation about it being the same or different people performing the action. Our image of persistence is not of a household continuing all their behaviors but that fixed fraction of all households are performing that action at any given time. Some households that have in the past, shut off the lights more frequently will stop this behavior. Some households that did not practice that behavior will start. In this way it is very much like a cold or a disease. We can think of the population as being mostly healthy (i.e., conservers), with our "energy public health" policy object being to

convert (cure) a large fraction of the non-conservers, while keeping as many conservers as "healthy" as possible.

[137] Again, see the discussion of the "Epochs" of environmental regulation in Section 1, by reference to the work of Mazmanian and Kraft (1999), where the Epoch 1, 2 & 3 formulation is presented.

[138] This "concern, capacity and conditions" model was first presented by the WSU/CEC research team to account for observed variation in commercial and government conservation adoption in California during the summer of 2001 crisis period (see Janda et al. 2002). However, we believe that it fits equally well in the case of residential consumer choice. For a related formulation related to environmentally-significant behavior in general, see Stern (2002).

[139] Our survey data are not rich enough to allow us to fully specify the model. Further study is indicated, however, to explore the links between knowledge, resources and action.

[140] See Stern (1992), Katzev and Johnson (1987), and Lutzenhiser (1993, 2002b) for discussion of social psychological research on energy conservation. See Bender et al. (2002) for a discussion of the elements of effective social marketing in the 2001 California *Flex Your Power* energy conservation campaign.

[141] Unfortunately, current data do not allow us to identify the relative proportions of those who are disinterested, feel unable to respond, etc.

[142] The NYSERDA "Keep Cool" campaign is primarily focused on buy-back of room AC units, with an advertising campaign and longer-term market transformation goals.

[143] See the discussion of the Puget Sound Energy experience in Lutzenhiser et al. 2003.

[144] In fact, windfall benefits accrue to those who already have an optimal off-peak usage pattern and new costs accrue to those with higher on-peak usage and limited ability to reduce or shift loads.

[145] For example, see CEC (2003), Nagihan (2003), Lutzenhiser et al. (2003).

[146] York, D. and M. Kushler. 2003. *America's Best: Profiles of America's Leading Energy Efficiency Programs*. Report Number U032. Washington, D.C.: American Council for an Energy-Efficiency Economy.

[147] *California Energy Commission Survey of Public Benefit Programs of Publicly-Owned Utilities in California.* 1999. Electricity Analysis Office.

[148] Senate Bill 5x, Section 1 (c). (Statutes of 2001)

[149] For a full description of the program elements see *Final 2002 Report: Evaluation of the California Energy Commission's AB29x and SB5x Peak Load Reduction Program Elements*. May 5, 2003. Prepared by Nexant for the California Energy Commission and the California State Legislature. Commission Publication 400-09-070.